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DEVELOPMENT OF A SIMPLE PORTABLE DETECTION KIT FOR SELECTED EXPLOSIVES

by
Robert E. Wyant
Battelle Columbus Laboratories
500 King Avenue
Columbus, Ohio 43201

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An explosive detection spray system has been developed which will detect explosive residues on the exterior of letter and package bombs. The detection is through the formation of colored reaction products using select spray reagents. Reagents were screened for shelf life and toxicity. The wavelength of absorbence and absorptivity of the reagent explosive complex was determined. The spray reagent of choice capable of detecting 0.4 micrograms TNT is prepared by adding 5 grams 1,3-diphenylacetone and 5 milliliters 20 percent tetraethylammonium hydroxide in methanol to 100 milliliters ethanol. RDX and Nitrate esters are detected at the 0.4 microgram level by spraying the substrate with a suspension of 10 grams of zinc dust in

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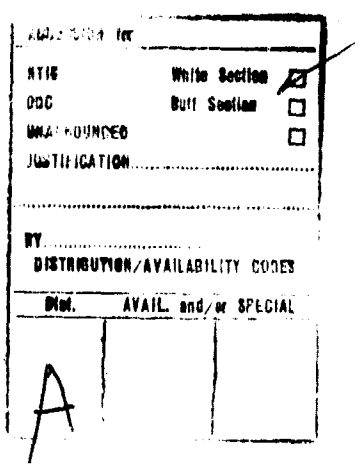
benzene, followed by a solution of 0.35 grams of procaine and 0.35 grams N,N-dimethyl-1-naphthylamine in 100 milliliters of a 50/50 acetic acid /distilled water mixture.

FORENORD

Specific reagents have been identified which will form colored reaction products with TNT, RDX and Nitrate esters (PETN, EGDN). Leather was shown to be the only common material incompatible with the spray. A decrease in sensitivity was observed on dark-colored paper because the reaction product and the background were similar in color. The high sensitivity of these reagents (0.4 µg) and their low expected false alarm rate should provide an explosive detection capability suitable for letter and package bombs.

Future work will be conducted at Naval Explosive Ordnance Disposal Facility. The spray's maximum sensitivities will be determined under ideal conditions using white filter paper and under real-world conditions using typical envelopes and flats which have arrived at NAVEODFAC via the U.S. Mail. Common materials which may give false alarms, and the feasibility of using the two sets of sprays sequentially will also be investigated. The result will be an inexpensive easy-to-use spray detection kit with known real-world sensitivity.



DR. LYLE MALOTKY
Project Officer
Naval Explosive Ordnance Disposal Facility

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INTRODUCTION

Recently, the sending of explosive devices, even as letter bombs, package bombs, and luggage bombs through the mail, and the use of explosive devices against both the civilian and military population has increased in certain nations. While not yet a major problem in the United States, the possibility of it becoming a serious problem should not be overlooked. Not knowing whether a suspicious looking letter or package contains explosives and is likely to detonate, produces anxiety among people who must handle these packages, and those concerned with their safety. It is known that small quantities of explosives are sometimes deposited on the outer surface of letter bombs and packages during the preparation of the explosive device. Most explosives used in the preparation of such a device have sufficient vapor pressure at ambient conditions to diffuse traces of these explosives to the surface. These small quantities of explosives should be detectable under proper conditions. Currently there are no test kits available that are specifically designed to detect trace quantities of explosives. Hence this program was initiated to develop such a kit.

The proposed study is designed to develop a simple, portable kit which will permit a person to determine whether a suspicious looking letter or package contains explosives. The test kit should be simple, easy to operate, and give the results rapidly. It is preferable that the test reagent be colorless or at least very light in color. It is recognized that more than one consecutive reagent may be required in order to give a definite answer. Further, the test reagent should be nontoxic and should be safe if sprayed on humans. The test reagent spray should not deface the letters or packages in any way, should be specific for explosives, and give no false positive or negative detections. Finally, the test reagent should show good sensitivity since the quantities of explosive being detected are likely to be quite small. The capability to distinguish between explosives is highly desirable, but this does not appear feasible with a single reagent. However, it should be possible to do this with a series of several reagents. Specifically, this study is concerned with: (1) the study of the chemistry of the various classes of explosives likely to be found in letter bombs and package bombs, with special emphasis on their color forming reactions; (2) the study of the color forming reactions to determine which ones might be suitably specific and adaptable to a test kit; and (3) the design of the test kit.

In summary, the kit resulting from this project should:

(1) Have the ability to detect very low surface densities of dynamite, trinitrotoluene, RDX, and pentaerythritol tetranitrate.

(2) Be specific and give few false positive reactions and if possible the common inferences for the test should be known.

(3) Use reactants which are not extremely toxic or highly corrosive.

(4) Involve a maximum number of three or four spray reagents.

(5) Have a shelf life of at least three months.

In addition, it would be highly desirable that the kit be able to differentiate among the various types of explosives and should be nonstaining and noncorrosive on the common surfaces on which it will be used. These surfaces include paper of all types, leather, and certain plastics which are used in the manufacture of luggage.

Those explosives that are currently of prime interest include the following.

(1) Dynamite (NG and EGDN)

(2) 2,4,6-Trinitrotoluene (TNT)

(3) Cyclonite (RDX)

(4) Pentaerythritol tetranitrate (PETN).

RESULTS

The properties of those reagents for the detection of TNT, the nitrate esters (NG, PETN and EGDN), and RDX that were selected for further consideration are presented in Tables A1, A2 and A3. As can be seen from the tables, a number of reagents, potentially useful to the 0.4 microgram level, have been identified for all three classes of explosives.

The toxicity data were all obtained from "The Toxic Substance List," 1974, ed., H. Christiansen, ed., U. S. Department of Health, Education and Welfare, HEW Pub. No. (NIOSH)74-134. It should be kept in mind that when the toxicity data are listed as unknown it merely means that the data are not presented in the compilation. Time did not permit a literature search to determine whether the data were available elsewhere.

The candidate reagents for the detection of TNT, nitrate esters and RDX were thoroughly evaluated and a number of potential reagents eliminated. Selected reagents were then given a second evaluation to determine whether the results previously obtained were reproducible. Following this step even more reagents were eliminated from consideration, leaving only three candidate reagents for the detection of TNT and six candidate reagents for the detection of the nitrate esters and RDX.

Storage tests were conducted on these reagents, and their ability to detect the explosives of interest on a variety of substrates was examined. The subject of possible interferences present in the various substrates is also addressed. Finally, a single reagent was selected for each of the three classes of explosives of interest.

2,4,6-Trinitrotoluene (TNT)

At the end of the broad reagent screening portion of this program a total of 45 candidate reagents for the detection of TNT remained. The first step in elimination of some of the reagents from further consideration was a thorough evaluation of all the candidates. This involved carrying out the color generation in solution and measuring the absorption maximum and the absorptivity. The result of this evaluation is presented in Table A4. On the basis of these experiments 11 of the reagents were selected for further evaluation. The thorough evaluation of these 11 reagents was then repeated to determine the reproducibility of the reagent systems. The comparison of the results of the two series of experiments are collected in Table A5.

Although the comparisons between the two series of experiments do not agree well in some instances, three candidate reagent systems were selected for further consideration. These reagent systems are:

(1) 1,3-Diphenylacetone-Et_4NOH

(2) Cyclopentanone-Et_4NOH

(3) Nitromethane-ET_4NOH

All of these reagents employ ethanol as the solvent. All three reagents were subsequently prepared and stored at room temperature for a period of five weeks, with the sensitivity of the reagent being checked weekly and any color change in the reagent noted. The results of these storage tests are shown in Table A6. Although all three reagents undergo a color change on storage, this does not appear to affect their ability to detect low levels of TNT. All reagents were capable of detecting 0.4 μg of TNT at the end of five weeks of storage. The color of the reagents seemed to stabliize after about two weeks; no further color changes were noted after this period. It is anticipated that these systems will be stable for an even longer period, but time did not permit further storage tests. Since the reagent based on 1,3-diphenylacetone underwent the least color change, this is the reagent of choice.

Since all three reagents had the same capability for the detection of TNT when freshly prepared, only one of the systems, cyclopentanone-ET_4NOH, was examined for its ability to detect TNT in the various substrates. A total of 34 substrates was examined and these results are presented in Table A7. With the possible exception of leather, the reagent responded satisfactorily on all the substrates. On leather

it is impossible to detect small quantities of TNT, but this could possibly be due to the fact that the color of the leather (brown) obscured the positive response of the small amounts of explosive.

The reagent of choice for the detection of TNT is based on 1,3-diphenylacetone and tetraethylammonium hydroxide in methanol. The spray reagent is prepared by adding 5 grams 1,3-diphenylacetone and 5 milliliters 20 percent tetraethylammonium hydroxide in methanol to 100 milliliters ethanol. When the system described above is used as a spray reagent the presence of TNT produces a red or red-orange color. This reagent is sensitive to at least the 0.4 μg level of TNT and may be useful at even lower levels. No tests were conducted at lower levels.

This reagent is reported to be specific for polynitro aromatic compounds. Thus it will detect compounds other than TNT, and these other polynitro aromatic compounds could be considered as interferences for this test. However, consultation with paper and packaging experts indicate that such compounds are not very likely to be encountered in the various substrates. No polynitro aromatics are used in the preparation of various types of paper, cardboard, or other substrates of interest, nor are they used as additives to these substrates. Thus a positive response to this reagent on various substrates probably indicates the presence of TNT.

Nitrate Esters

At the end of the broad reagent screening portion of this program almost 100 candidate reagents remained under consideration. A thorough evaluation of most of these reagents was the first step in reducing the number of potential reagents. This involved carrying out the color generation reactions in solution and measuring the absorption maximum and the molar absorptivity. The results of these experiments are collected in Table A8. No reagents involving azulene were examined. Based on the results of these experiments 36 of the candidate reagents were selected for further examination. These reagents were reexamined to determine the reproducibility of the reagent systems. The comparison of the results of the two experiments are collected in Table A9. It can be seen from this table that much better agreement between the two experiments was obtained than was obtained with the TNT reagents. On the basis of these results six reagents were selected for further examination. All gave molar absorptivities around 50,000 and yielded a red color. These reagents included the following.

(1) p-Aminobenzoic acid
N-Phenyl-1-naphthylamine

(2) p-Aminoacetophenone
N-Phenyl-1-naphthylamine

(3) Diaminodiphenylsulfone
N-Phenyl-1-naphthylamine

(4) p-Aminobenzonitrile
N-Phenyl-1-naphthylamine

(5) Procaine
N,N-Dimethyl-1-naphthylamine

(6) Sulfanilamide
N-Phenyl-1-naphthylamine

All the reagents are prepared in 50/50 acetic acid/water and are applied following a spray of zinc dust in benzene.

All six of the reagents described above were subsequently prepared and stored at room temperature for a period of five weeks, with the sensitivity of the reagent being checked weekly and any color change in the reagent noted. The results of this study are presented in Table A10. All of the reagents developed some color on storage. However this color did not deter from the reagents' ability to detect low levels of the nitrate esters. All detected the nitrate ester at 0.4 μg even after five weeks of storage. There is every reason to believe that this reagent is stable indefinitely since it is merely a solution of a primary aromatic amine and a coupling agent in aqueous acetic acid. These two components should not react with each other. As mentioned previously, all the reagents developed a slight amount of color but this color is probably due to the traces of nitrate ion present in the water supply. The reagent that developed the least color is based on procaine and N,N-dimethyl-1-naphthylamine, and this is the reagent of choice for the nitrate ester detection.

Since all six reagents had the same sensitivity when freshly prepared, only the reagent consisting of procaine and N,N-dimethyl-1-naphthylamine was examined for its ability to detect PETN on the various substrates. A total of 34 various substrates were examined and the results of this experiment are presented in Table A11. As can be seen from these results, the reagent has good sensitivity on almost all of the substrates. In the case of the one leather sample examined, no positive response was obtained. The leather turned very dark brown, possibly obscuring the positive response, and became very brittle. In the case of polyethylene and polyvinyl chloride the colors faded and with several of the dark brown substrates quantities less than 100 micrograms of PETN could not be readily detected. It was also noted that in one instance a weak positive response was given by the glue on one of the envelopes. In summary, this reagent appears to work well on most of the substrates.

The reagent of choice is prepared by dissolving 0.35 grams of procaine and 0.35 grams of N,N-dimethyl-1-naphthylamine in a 100 milliliter mixture of 50/50 acetic acid/distilled (or deionized) water. It should

be pointed out that the use of distilled water is very important in the preparation of this reagent. The use of ordinary tap water is likely to result in a highly colored reagent because of the presence of nitrite ion. This reagent is applied as a spray following a spray of a suspension of 10 grams of zinc dust in 100 milliliters of benzene. The presence of nitrate esters is indicated by the development of a red or red-violet color. This reagent is sensitive to at least the 0.4 μg level of the nitrate esters and may be useful at even lower levels. However no tests were conducted at lower levels.

This reagent is specific for nitrite ion or compounds that will liberate nitrate ion under the conditions of the test. Thus, RDX is also detected by this reagent. However in consultations with paper and packaging experts it has been determined that neither nitrite ion (nitrite salts) nor nitrite ion releasing compounds are a usual component or additive to the substrates of interest. Thus this reagent system should be specific for the nitrate esters and RDX.

RDX

At the end of the broad reagent screening portion of this program almost 80 potential RDX reagents were still under consideration. In order to eliminate a number of these reagents from further consideration the first step was the thorough evaluation of most of these reagents. This involved carrying out the color generation reaction in solution and measuring the absorption maximum and molar absorptivity of each reagent system. The results of these studies are presented in Table A12. It should be pointed out that no azulene-based reagents were examined. On the basis of these experiments 36 reagents were selected for further study. These are essentially the same reagents selected for the detection of the nitrate esters. These reagents were reexamined to determine the reproducibility of the two experiments. The results of this comparison is presented in Table A13. As can be seen from this table, very good agreement was obtained in the two experiments. On the basis of these results six of the reagents were selected for continued study. The selected reagents are the same ones selected for the nitrate ester determination. All give red colors in the presence of RDX and exhibit molar absorptivities in the 50,000 range. All use 50/50 acetic acid/water as the solvent and are applied following the zinc dust spray. The reagents selected are listed below.

(1) p-Aminobenzoic acid
N-Phenyl-1-naphthylamine

(2) p-Aminoacetophenone
N-Phenyl-1-naphthylamine

(3) Diaminodiphenylsulfone
N-Phenyl-1-naphthylamine

(4) p-Aminobenzonitrile
N-Phenyl-1-naphthylamine

(5) Procaine
N,N-Dimethyl-1-naphthylamine

(6) Sulfanilamide
N-Phenyl-1-naphthylamine

All six of the above reagents were prepared and put on storage tests for five weeks at room temperature, with the sensitivity and any color change in the reagent being noted weekly. The results of these storage tests are presented in Table A14. In storage, all the reagents developed a slight color but this did not interfere with the reagents' ability to detect RDX. All six reagents responded to RDX at the 0.4 μg level even after five weeks of storage. It is anticipated that these reagents are stable indefinitely and that the color will not change to any extent since most of the color was present initially and did not deepen in storage. That reagent with the least color was based on procaine-N,N-dimethyl-1-naphthylamine, and this is the reagent of choice.

The reagent consisting of Procaine and N,N-dimethyl-1-naphthylamine was selected as being representative of the six reagents, and its ability to detect RDX on various substrates was examined. A total of 34 substrates were examined and the results are collected in Table A15. The sensitivity of this reagent for RDX on the various substrates appears to be adequate for its intended purpose. With the exception of leather, the reagent detected RDX on all the substances. In the case of the one leather sample examined it turned very dark brown, possibly obscuring a positive response and became very brittle. Although in several instances the RDX detection limit was 40 micrograms, in most instances the detection level was 4.0 or 0.4 micrograms of RDX. In one instance the glue on one of the substrates did give a weak positive response. In summary, a reagent of this type does appear to be usable on a variety of substrates.

The reagent of choice for the detection of RDX is the same reagent chosen for nitrate ester detection, and is prepared by dissolving 0.35 grams of procaine and 0.35 grams of N,N-dimethyl-1-naphthylamine in 100 milliliters of a mixture 50/50 acetic acid/distilled (or deionized) water. It is important to use distilled water since the use of ordinary tap water is likely to result in a highly colored reagent because of the presence of nitrite ion in the water. This spray reagent is applied following a spray of a suspension of 10 grams zinc milliliters benzene. A positive response is evidenced by the development of a red or red-violet color. This reagent is sensitive to at least the 0.4 μg level of RDX and may be useful to even lower levels but we did no studies at lower levels.

This reagent is specific for nitrite ion or compounds that will liberate nitrite ion under the conditions of the test. Thus the nitrate esters will also respond to this reagent. However paper and packaging experts report that neither nitrite ion (nitrite salts) nor nitrite ion releasing compounds are a usual component or additive to the substrates of interest. Thus this reagent system should be specific for RDX and the nitrate esters.

APPENDIX A
PROPERTIES OF DETECTION REAGENTS AND REACTION PRODUCTS

TABLE A-1. SUMMARY OF PROPERTIES OF CANDIDATE REAGENTS FOR 2,4,6-TRINITROTOLUENE

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
1,4-Diazabicyclo[2,2]octane	Chloroform	Red	Colorless	Colorless	0.4	Comm.[a]	Unk.[b]
Bis(9-julolidyl)methane	Chloroform	Violet	Colorless	Colorless	0.4	Synthetic	Unk.
1,5-Diazabicyclo[5.4.0]undec-5-ene	Chloroform	Red	Colorless	Colorless	0.4	Comm.	Unk.
1,5-Diazabicyclo[4.3.0]non-5-ene	Chloroform	Red	Colorless	Colorless	0.4	Comm.	Unk.
1,8-Bis(dimethylamino)naphthalene	Chloroform	Red	Colorless	Colorless	0.4	Comm.	Unk.
2,3,5,6-Tetramethyl-p-phenylene-diamine	Chloroform	Blue-violet	Colorless	Colorless	0.4	Comm.	LDLo[c] ~ 20 mg/kg.
4,4-Dimethoxy-2-butanone, Et_4NOH	Ethanol	Red	Colorless	Orange	0.4	Comm.	Unk.; LDLo 102 mg/kg.
1,3-Diphenylacetone, Et_4NOH	Ethanol	Red-orange	Colorless	Orange	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Phenyl-2-propanone, Et_4NOH	Ethanol	Red	Colorless	Yellow	0.4	Comm.	Unk.; LDLo 102 mg/kg.
5-Hexene-2-one, Et_4NOH	Ethanol	Red-violet	Colorless	Orange, odorous	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Acetophenone, Et_4NOH	Ethanol	Red-violet	Colorless	Orange, odorous	0.4	Comm.	LD50[d] 3000 mg/kg; LDLo 102 mg/kg.
3-Methyl-2-hexanone, Et_4NOH	Ethanol	Red-violet	Colorless	Yellow	0.4	Comm.	LD50 ~ 2500 mg/kg.; LDLo 102 mg/kg.
Fluorene, Et_4NOH	DMF·H_2O	Red	Colorless	Colorless	0.4	Comm.	TDLo[e] 15g/kg.; LDLo 102 mg/kg.
1,3-Bis(dimethylamino)2-propanol	Chloroform	Violet	Colorless	Straw	0.4	Comm.	LD50 ~ 1500 mg/kg.
Ethanolamine	Chloroform	Orange	Colorless	Colorless	0.4	Comm.	LD50 2100 mg/kg.
N-Ethyldiethanolamine	Chloroform	Red	Colorless	Colorless	0.4	Comm.	LD50 ~ 1000 mg/kg.
Tetraethylammonium hydroxide	DMF	Brown	Colorless	Colorless	0.4	Comm.	LDLo 102 mg/kg.
Diethylamine	DMSO	Violet	Colorless	Colorless	0.4	Comm.	LD50 540 mg/kg.
Propylenediamine	DMF	Violet	Colorless	Colorless	0.4	Comm.	LD50 2230 mg/kg.
Piperazine	DMF	Violet	Colorless	Colorless	0.4	Comm.	LD50 ~ 11 g/kg.
Potassium hydroxide	Methyl Cellosolve	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 365 mg/kg.

TABLE A-1 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
$SnCl_2$-dimethylaminobenzaldehyde	1MHCl-Ethanol	Yellow	Lt. Yellow	Colorless	0.4	Comm.	LD50 620 mg/kg.
$SnCl_2$-diphenylacrolein	1MHCl-Ethanol	Yellow	Lt. Yellow	Colorless	0.4	Comm.	LD50 ~ 3500 mg/kg.
$SnCl_2$-N)4-pyridyl)pyridinium chloride	1MHCl-1N NaOH	Red-orange	Lt. Yellow	Tan	0.4	Comm.	Unk.
Cyclohexanone, Et_4NOH	Ethanol	Red	Colorless	Lt. Yellow	0.4	Comm.	LD50 1620 mg.; LDLo 102 mg/kg.
Cyclopentanone, Et_4NOH	Ethanol	Red	Colorless	Lt. Orange	0.4	Comm.	LD50 2950 mg/kg. LDLo 102 mg/kg.
Propiophenone, Et_4NOH	Ethanol	Red	Colorless	Yellow	0.4	Comm.	LD50 4490 mg/kg.; LDLo' 102 mg/kg.
3-Acetyl-1-propanol, Et_4NOH	Ethanol	Red-violet	Colorless	Lt. Orange	0.4	Comm.	Unk.; LDLo' 102 mg/kg.
Benzalacetone, Et_4NOH	Ethanol	Red-violet	Colorless	Lt. Orange	0.4	Comm.	Unk.; LDLo 102 mg/kg.
1-Phenyl-2-butanone, Et_4NOH	Ethanol	Red-orange	Colorless	Lt. Orange	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Phenylacetonitrile, Et_4NOH	Ethanol	Red-orange	Colorless	Colorless	0.4	Comm.	LD50 270 mg/kg.; LDLo 102 mg/kg.
3,4-Dimethoxyphenylacetonitrile, Et_4NOH	Ethanol	Red	Colorless	Colorless	0.4	Comm.	Unk.
Nitromethane, Et_4NOH	Ethanol	Red-orange	Colorless	Colorless	0.4	Comm.	LD50 940 mg/kg.; LDLo 102 mg/kg.
Phloroglucinol, Et_4NOH	Ethanol	Orange	Colorless	Colorless	0.4	Comm.	LDLo 1550 mg/kg.; LDLo 102 mg/kg.
Tetramethylammonium hydroxide	Ethyl cellosolve	Violet	Colorless	Colorless	0.4	Comm.	LDLo ~ 102 mg/kg.
Diphenylamine, Et_4NOH	Acetone-methanol	Violet	Colorless	Colorless	0.4	Comm.	LDLo ~ 200 mg/kg.; LDLo 102 mg/kg.
Ethylenediamine	DMSO	Violet	Colorless	Colorless	0.4	Comm.	LD50 ~ 150 mg/kg.
4,4'-Bis(dimethylaminophenyl) methane	Chloroform	Red-orange	Colorless	Colorless	0.4	Comm.	LD50 681 mg/kg.

TABLE A-1 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
p-Chlorophenylacetonitrile, Et_4NOH	Ethanol	Red	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
o-Methoxyphenylacetonitrile, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
p-Methoxyphenylacetonitrile, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
$SnCl_2$-2-bromo-4-dimethylamino-benzaldehyde	IMHCl-Ethanol	Orange	Colorless	Colorless	0.4	Synthetic	LD50 ~ 620 mg/kg.
$SnCl_2$-2-phenoxy-4-dimethylamino-benzaldehyde	IMHCl-Ethanol	Orange	Colorless	Colorless	0.4	Synthetic	LD50 ~ 620 mg/kg.
$SnCl_2$-4-diphenylaminobenzalde-hyde	IMHCl-Ethanol	Red-orange	Colorless	Straw	0.4	Synthetic	LD50 ~ 620 mg/kg.
$SnCl_2$-4-dimethylaminocinnam-aldehyde	IMHCl-Ethanol	Violet	Colorless	Tan	0.4	Synthetic	LD50 ~ 620 mg/kg.
$SnCl_2$-2-Chloro-4-dimethylamino-benzaldehyde	IMHCl-Ethanol	Orange	Colorless	Colorless	0.4	Synthetic	LD50 ~ 620 mg/kg.
$SnCl_2$-2-hydroxy-1-naphth-aldehyde	IMHCl-Ethanol	Orange	Colorless	Straw	0.4	Comm.	Unk.
$SnCl_2$-2,5-dimethoxy-4-dimethyl-aminobenzaldehyde	IMHCl-Ethanol	Orange	Colorless	Yellow	0.4	Synthetic	LD50 ~ 620 mg/kg.
$SnCl_2$-2-methyl-4-dimethyl-aminobenzaldehyde	IMHCl-Ethanol	Orange	Colorless	Colorless	0.4	Synthetic	LD50 ~ 620 mg/kg.
Fast Blue BB	Water	Orange	Tan	Straw	0.4	Comm.	Unk.
Fast Blue R	Water	Violet	Tan	Lt. Green	0.4	Comm.	Unk.
Variamine Blue B	Water	Violet	Yellow	Lt. Brown	0.4	Comm.	Unk.
Sodium sulfite-Griess Reagent	H_2O, 50/50 $HOAC/H_2O$	Orange	Colorless	Colorless	0.4	Comm.	LD50 ~ 2g/kg.; LDLo 150 mg/kg.

TABLE A-I (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
2,4-Pentanedione, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	LD50 1000 mg/kg.; LDLo 102 mg/kg.
p-Nitrosodimethylaniline	Acetone, H_2O	Orange	Yellow	Green	0.4	Comm.	LD50 65 mg/kg.
1,3-Dicarbomethoxyacetone, Et_3N	Ethanol	Orange	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Flavone, Et_4NOH	Ethanol	Violet	Colorless	Straw	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Nitron	Chloroform	Violet	Lt. Yellow	Red	0.4	Comm.	Unk.
α-Naphthoflavone, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Khellen, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
2,6-Dimethyl-dipyrone, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Testosterone, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Cholestan-3-one-Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Methyltestosterone, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
Progesterone, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	TDLo 120 mg/kg.; LDLo 102 mg/kg.
Pregnenolone, Et_4NOH	Ethanol	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 102 mg/kg.
$TiCl_3$-p-dimethyaminobenz-aldehyde	IMHCl-EtOH	Yellow	Grey	Colorless	0.4	Comm.	LD50 620 mg/kg.
$TiCl_3$- diphenylacrolein	IMHCl-EtOH	Yellow	Grey	Colorless	0.4	Comm.	LD50 ∿ 3500 mg/kg.
$TiCl_3$-N(4-pyridyl)pyridinium chloride	IMHCl-IN MeOH	Red-orange	Cream	Tan	0.4	Comm.	Unk.
$TiCl_3$-p-dimethylaminocinnam-aldehyde	IMHCl-EtOH	Violet	Grey	Yellow	0.4	Comm.	Unk.
$SnCl_2$-2,5-dimethoxytetrahydro-furan-p-dimethylaminobenz-aldehyde	HCl	Violet	Colorless	Lt. Yellow	0.4	Comm.	Unk.; LD50 620 mg/kg.

TABLE A-1 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
$SnCl_2$-Vanillin	IMHCl-EtOH	Yellow	Colorless	Colorless	0.4	Comm.	LD50 1580 mg/kg.
$T.Cl_3$-Ninhydrin-p-dimethylamino-benzaldehyde	IMHCl-Pyridine-Ethanol	Orange	Colorless	Colorless	0.4	Comm.	LDLo 250 mg/kg.; LD50 620 mg/kg.

(a) Comm. - Commercial.

(b) Unk. - Unknown.

(c) LDLo - Lethal Dose Low - the lowest dose of a substance other than LD50 introduced by any route other than inhalation over any given period of time and reported to have caused death in man or the lowest dose introduced in one or more divided portions and reported to have caused death in animals.

(d) LD50 - Lethal Dose - 50 percent kill.

(e) TDLo - Toxic Dose Low - the lowest dose of a substance, as published or made available to publish, introduced by any route other than inhalation over any given period of time and reported to produce any toxic effect in man or to produce carcinogenic, teratogenic, mutagenic or neoplastigenic effects in humans or animals.

TABLE A-2 SUMMARY OF PROPERTIES OF CANDIDATE REAGENTS FOR NITRATE ESTERS

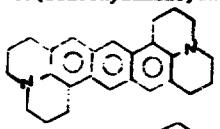
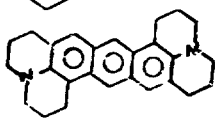
Reagent	Solvent	Color Response	Background Color	Reagent Color	Sensitivity, Micrograms	Reagent Availability	Toxicity of Reagent
2,6-Bis(dimethylamino)anthracene	Benzene	Red-Orange	Colorless	Yellow	0.4	Synthetic	Unk.[d]
2,6-Bis(dimethylamino)anthracene	Chloroform	Violet	Yellow	Yellow	0.4	Synthetic	Unk.
	Benzene	Violet	Yellow	Tan	0.4	Synthetic	Unk.
	Chloroform	Blue-Violet	Yellow	Tan	0.4	Synthetic	Unk.
4,4",4" Methylidynetris (N,N-dimethylaniline)	Acetone	Violet	Colorless	Lt Violet	0.4	Synthetic	Unk.
3,3,-Bis(p-dimethylaminophenyl) 2-methoxy-p-cresol	Acetone	Blue	Colorless	Lt Red-Violet	0.4	Synthetic	Unk.
N,N'-Diphenylbenzidine	Acetone	Blue(NV)	Colorless	Colorless	0.4	Comm.[c]	Unk.
DBH[a]-Griess Reagent	EtOH-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50~2 g/Kg; LDLo 150 mg/Kg
DBU[b]-Griess Reagent	EtOH-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50~2 g/Kg; LDLo 150 mg/Kg
1N EtOH-Griess Reagent	H_2O-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50~2 g/Kg; LDLo 150 mg/Kg
3,3-Bis(p-dimethylaminophenyl)-o-cresol	Acetone	Green	Colorless	Tan	0.4	Synthetic	Unk.
4-Chloro-3,3-bis(p-dimethylamino-phenyl)-o-cresol	Acetone	Green	Colorless	Straw	0.4	Synthetic	Unk.
4,4'-(2-Thenylidene)bis(N,N-dimethylaniline)	Acetone	Green	V Lt Green	Straw	0.4	Synthetic	Unk.
3,3-Bis(p-dimethylaminophenyl)-p-cresol	Acetone	Violet	V Lt OViolet	Orange	0.4	Synthetic	Unk.
3,3-Bis(p-dimethylaminophenyl)-6-methoxy-m-toluenesulfonic and sodium salt	Ethanol	Green	Colorless	Colorless	0.4	Synthetic	Unk.

TABLE A-2 (Continued)

Reagent	Solvent	Color Response	Background Color	Reagent Color	Sensitivity, Micrograms	Reagent Availability	Toxicity of Reagent
DBH-p-Nitroaniline-N(1-naphthyl)-ethylenediamine	EtOH-HOAC/H_2O	Red-Violet	Colorless	Lt Yellow	0.4	Comm.	LD50 3249 mg/Kg; LDLo 150 mg/Kg
DBH-p-Chloroaniline-N(naphthyl)-ethylenediamine	EtoH-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 300 mg/Kg; LDLo 150 mg/Kg
DBH-p-toluidene-N(1-naphthyl)-ethylenediamine	EtOH-HOAC/H_2O	Blue-Violet	Colorless	Colorless	0.4	Comm.	LD50 1285 mg/Kg; LDLo 150 mg/Kg
DBH-Procaine-N(1-naphthyl)-ethylenediamine	EtOH-HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 500 mg/Kg; LDLo 150 mg/Kg
DBH-2-Naphthylamine-6,8-disulfonic acid N(1-naphthyl)ehtylenediamine	EtOH-HOAC/H_2O	Blue-Violet	Colorless	Colorless	0.4	Comm.	Unk. LDLo 150 mg/Kg
DBH-Sulfanilic acid-N,N-dimethyl-naphthylamine	EtOH-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50- 2 g/Kg; LD50-1400 mg/Kg
DBH-p-Nitroaniline-N,N-dimethyl-1-naphthylamine	EtOH-HOAC/H_2O	Red Violet	Colorless	Lt Yellow	0.4	Comm.	LD50 3249 mg/Kg. LD50-1400 mg/Kg
DBH-p-Chloroaniline-N-N-dimethyl-1-naphthylamine	EtOH-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm	LD50 300 mg/Kg: LD50-1400 mg/Kg
DBH-procaine-N,N-dimethyl-1-naphthylamine	EtOH-HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 500 mg/Kg; LD50-1400 mg/Kg
DBH-7-naphthylamine-6,8-disulfonic acid-N,N-dimethyl-1-naphthylamine	EtOH-HOAC/H_2O	Blue-Violet	Colorless	Colorless	0.4	Comm.	Unk.
DBH-N,N,N^1,N^1-Tetramethyl-p-phenylenediamine	Acetic acid	Blue	Colorless	V Lt Blue	0.4	Comm.	LD50-50 mg/Kg
DBH-Glyoxal bis(N,N-diphenyl-hydrazone)	Acetic acid	Pink	Tan	Red	0.4	Synthetic	Unk.
DBH-3-Methyl-2-benzothiazolinone-Picryl-hydrazone	Acetic acid	Orange	Colorless	Orange	0.4	Synthetic	Unk.

TABLE A-2 (Continued)

Reagent	Solvent	Color Response	Background Color	Reagent Color	Sensitivity, Micrograms	Reagent Availability	Toxicity of Reagent
DBH-N,N,N^1,N^1-Tetramethylbenzidine	Acetic acid	Orange	Colorless	Colorless	0.4	Comm	Unk.
DBH-N,N-Diphenyl-p-phenylenediamine	Acetic acid	Orange-Red	Colorless	V Lt Blue-Green	0.4	Comm.	LD50 2370 mg/Kg
DBH-Indole	Water-HCl	Violet	Colorless	Colorless	0.4	Comm.	LD50 1000 mg/Kg
DBH-Sulfanilic acid Phenol	HOAC/H_2O 1M NaOH	Orange	Colorless	Colorless	0.4	Comm.	LD50 2g/Kg LD50 414 mg/Kg
DBH-1-Naphthylamine-7-sulfonic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Brown-Orange	Colorless	Colorless	0.4	Comm.	Unk. LDLo 150 mg/Kg
DBH-Sulfanilic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 2 g/Kg LD50 150 mg/Kg
DBH-1-Aminopyrene	HOAC	Yellow	Colorless	Colorless	0.4	Comm.	LD50 1070 mg/Kg
DBH-p-Aminobenzoic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/Kg LDLo 150 mg/Kg
DBH-4-Aminoacetophenone N-Phenyl-2-naphthylamine	HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/Kg LDLo 80 mg/Kg
DBH-o-Dianisidine m-Phenylenediamine	HOAC/H_2O	Brown	Colorless	Colorless	0.4	Comm.	LD50 1450 mg/Kg LDLo 50 mg/Kg
DBH-o-Tolidine	HOAC/H_2O	Orange-Brown	Colorless	Colorless	0.4	Comm.	LD50 404 mg/Kg
DBH-p-Aminosalicyclic acid N(1-naphthyl)ethylenediame	HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	LD50 4 g/Kg LDLo 150 mg/Kg
DBH-m-Phenylenediamine	HOAC/H_2O	Orange-Brown	Colorless	Colorless	0.4	Comm.	LDLo 80 mg/Kg
DBH-Indole	0.3MH_2SO_4	Violet	Colorless	Colorless	0.4	Comm.	LD50 1000 mg/Kg
DBH-o-Dianisidine 2-Naphthol	HOAC/H_2O-1MNaOH	Orange-Brown	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/Kg LD50 2480 mg/Kg
DBH-Dijulolidylmethane	HOAC	Blue	Lt Blue	Blue	0.4	Synthetic	Unk.
DBH-Sulfanilic acid m-Phenylenediamine	HOAL/H_2O	Brown-Orange	Colorless	Colorless	0.4	Comm.	LD50 2 g/Kg LDLo 80 mg/Kg
DBH-2-Ethoxy-3,6-diaminoacridine N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	LDLo 100 mg/Kg LDLo 150 mg/Kg

TABLE A-2 (Continued)

Reagent	Solvent	Color Response	Background Color	Reagent Color	Sensitivity, Micrograms	Reagent Availability	Toxicity of Reagent
DBH-p-Aminobenzoic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/Kg
DBH-p-Phenylazoaniline N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	LDLo 1600 mg/Kg LDLo 150 mg/Kg
DBH-Diaminodyphenylsulfone N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50~100 mg/Kg LDLo 150 mg/Kg
DBH-Anthranilic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Blue	Colorless	Colorless	0.4	Comm.	TDLo 4000 mg/Kg (g)
DBH-p-Aminobenzonitrite N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	Unk. LDLo 150 mg/Kg
DBH-3-Aminobenzotrifluoride N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	Unk. LDLo 150 mg/Kg
DBH-4-Amino-6-chloro-m-benzene-disulfonamide N(1-Naphthyl)-ethylenediamine	HOAC/H_2O	Blue-Violet	Colorless	Colorless	0.4	Comm.	Unk. LD50 3900 mg/Kg
DBH-Sulfanilamide N(1-Naphthyl)ethylenediamine		Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/Kg LDLo 150 mg/Kg
DBH-p-Aminobenzoic acid N,N-Dimethyl-1-naphthylamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/Kg LD50~1400 mg/Kg
DBH-4-Aminoacetophenone N,N-Dimethyl-1-naphthylamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/Kg LD50~1400 mg/Kg
DBH-Diaminodyphenylsulfone N,N-Dimethyl-1-naphthylamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50~100 mg/Kg LD50~1400 mg/Kg
DBH-p-Aminobenzonitrile N,N-Dimethyl-1-naphthlamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	Unk. LD50~1400 mg/Kg
DBH-3-Aminobenzotrifluoride N,N-Dimethyl-1-naphthylamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	Unk. LD50~1400 mg/Kg
DBH-Sulfanilamide N,N-Dimethyl-1-naphthlamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/Kg LD50~1400 mg/Kg

TABLE A-2 (Continued)

Reagent	Solvent	Color Response	Background Color	Reagent Color	Sensitivity, Micrograms	Reagent Availability	Toxicity of Reagent
DBH-p-Aminobenzoic acid 1-Amino-7-naphtholenesulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/Kg Unk.
DBH-4-Aminoacetophenone 1-Amino-7-naphthalenesulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/Kg Unk.
DBH-Diaminodiphenylsulfone 1-Amino-7-naphthalenesulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50~100 mg/Kg Unk.
DBH-p-Aminobenzonitrile 1-Amino-7-naphthalenesulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	Unk. Unk.
DBH-3-Aminobenzotrifluoride 1-Amino-7-Naphtholenesulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	Unk. Unk.
DBH-Sulfanilamide 1-Amino-7-naphthalenesulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/Kg Unk.
DBH-p-Aminobenzoic acid N-Phenyl-1-naphthylamine	HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/Kg Unk.
DBH-4-Aminoacetopherione N-Phenyl-1-naphthylamine	HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/Kg Unk.
DBH-p-Aminobenzoitrile N-Phenyl-1-naphthylamine	HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	Unk.
DBH-Sulfanilic acid N-Phenyl-1-naphthylamine	HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	LD50~2 g/Kg Unk.
DBH-Diaminodiphenylsulfone N-Phenyl-2-naphthylamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50~100 mg/Kg LDLo 80 mg/Kg
DBH-Sulfanilic acid 1,8-Naphthalenediamine	HOAC/H_2O	Blue	Tan	Brown	0.4	Comm.	LD50~2900 mg/Kg Unk.
Sulfanilamide 1,8-Naphthalenediamine	HOAC/H_2O	Blue	Tan	Brown	0.4	Comm.	LD50 3900 mg/Kg Unk.
DBH-1-Amino-4-Chloro-3-toluenesulfonic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	Unk. LDLo 150 mg/Kg

TABLE A-2 (Continued)

Reagent	Solvent	Color Response	Background Color	Reagent Color	Sensitivity, Microgram	Reagent Availability	Toxicity of Reagent
DBH-1-Amino-4-Chloro-3-toluenesulfonic acid 1,8-Naphthalenediamine	HOAC/H_2O	Blue	Tan	Brown	0.4	Comm.	Unk. Unk.
DBH-1-Amino-4-Chloro-3-toluenesulfonic acid 1-Amino-7-naphthalenesulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	Unk. Unk.
DBH-1-Amino-2,5-benzenedisulfonic acid 1,8-Naphthalenediamine	HOAC/H_2O	Blue	Tan	Brown	0.4	Comm.	Unk. Unk.
DBH-1-Amino-2,5-dichloro-4-benzene-sulfonic acid 1-Amino-7-naphthalenesulfonic acid	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk. Unk.
Zn-Sulfanilic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 2 g/Kg
Zn-Sulfanilamide N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/Kg LDLo 150 mg/Kg
Zn-Diaminodyphenylsulfone N(1-Naphthyl)ethylenediamine	HOAC	Violet	Colorless	Colorless	0.4	Comm.	LD50 100 mg/Kg LDLo 150 mg/Kg
Zn-p-Aminobenzonitrile N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk. LDLo 150 mg/Kg
Zn-p-Aminobenzoic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/Kg LDLo 150 mg/Kg
Zn-2-Naphthylamine-6,8-disulfonic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk. LDLo 150 mg/Kg
Zn-4-Aminoacetophenone N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/Kg LDLo 150 mg/Kg
Zn-1-Amino-7-naphtholenesulfonic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Brown	Colorless	Colorless	0.4	Comm.	Unk. LDLo 150 mg/Kg
Zn-p-Aminosalicylic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 4 g/Kg LDLo 150 mg/Kg
Zn-p-Aminobenzonitile N,N-Dimethyl-1-naphthylamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk. LD50 1400 mg/Kg
Zn-Di-o-anisidine 1-Amino-7-naphthalenesulfonic acid	HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/Kg Unk.

TABLE A-2 (Continued)

Reagent	Solvent	Color Response	Background Color	Reagent Color	Sensitivity, Micrograms	Reagent Availability	Toxicity of Reagent
Zn-p-Aminobeznoic acid 1-Amino-7-naptholenesulfonic acid	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/Kg Unk.
Zn-Sulfanilic acid 1-Amino-7-naphtholenesulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50~2 g/Kg Unk.
Zn-Diaminodiphenylsulfone Azulene	HOAC/H_2O	Violet	Lt Blue	Blue	0.4	Comm.	LD50~100 mg/Kg Unk.
Zn-4-Aminoacetophenone N-Phynel-2-naphthylamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/Kg LDLo 80 mg/Kg
Zn-Sulfanilic acid Dimethylaniline	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50~2 g/Kg LDLo 500 mg/Kg
Zn-p-Chloraniline N9L-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 300 mg/Kg LDLo 150 mg/Kg
Zn-p-Toluidine N(1-Naphthyl)etheylenediamine	HOAC/H_2O	Blue-Violet	Colorless	Colorless	0.4	Comm.	LD50 1285 mg/Kg LDLo 150 mg/Kg
Zn-Procaine N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 500 mg/Kg LDLo 150 mg/Kg
Zn-Di-o-anisidine N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Brown	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/Kg LDLo 150 mg/Kg
Zn-p-Aminobenzoic acid N(1-Naphthyl)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/Kg LDLo 150 mg/Kg
Zn-4-Aminoacetophenone N(1-Naphthal)ethylenediamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 300 mg/Kg LDLo 150 mg/Kg
Zn-Procaine N,N-Dimethyl-1-naphthylamine	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 500 mg/Kg LD50~1400 mg/Kg
Zn-5-Chloro-2-Aminoanisole 1-Naphthylamine-7-sulfonic acid	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk. Unk.
Zn-4-Aminoautophenone 1-Naphthalamine-7-sulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 300 mg/Kg Unk.
Zn-Diaminodiphenylsulfone 1-Naphtylamine-7-sulfonic acid	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50~100 mg/Kg Unk.

TABLE A-2 (Continued)

Reagent	Solvent	Color Response	Background Color	Reagent Color	Sensitivity, Micrograms	Regeant Availability	Toxicity of Reagent
Zn-p-Aminobenzonitrile 1-Naphthylamine-7-sulfonic acid	HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	Unk. Unk.
Zn-3-Aminobenzotrifluoride 1-Naphthylamine-7-sulfonic acid	HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	Unk. Unk.
Zn-Sulfanilamide 1-Naphthylamine-7-sulfonic acid	HOAC/H_2O	Red-Violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/Kg Unk.
Zn-Procaine Azulene	HOAC/H_2O	Violet	Lt Blue	Blue	0.4	Comm.	LD50 500 mg/Kg Unk.
Zn-p-Aminobenzoic acid N-Phenyl-1-naphthylamine	HOAC/H_2O	Blue	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/Kg Unk.
Zn-Diaminodiphenylsulfone N-Phenyl-1-naphthylamine	HOAC/H_2O	Blue	Colorless	Colorless	0.4	Comm.	LD50 100 mg/Kg Unk.
Zn-p-Aminobenzonitrile N-Phenyl-1-naphthylamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk. Unk.
Zn-Sulfanilamide N-Phenyl-1-naphthylamine	HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/Kg Unk.
Zn-N,N,N^1,N^1-Tetramethyl-p-phenylenediamine	HOAC	Blue	Colorless	Colorless	0.4	Comm.	LDLo 20 mg/Kg
Zn-Tetramethylbenzidine	HOAC	Yellow	Colorless	Colorless	0.4	Comm.	Unk.
Zn-Thio Michler's ketone	HOAC/H_2O	Blue	Lt Green	Green	0.4	Comm.	Unk.
Zn-Dijulolidylmethane	HOAC	Blue	Lt Blue	Lt Blue	0.4	Synthetic	Unk.
Zn-o-Tolidine	HOAC/H_2O	Brown	Colorless	Colorless	0.4	Comm.	LD50 404 mg/Kg
Zn-Di-oianisidine 2-naphthol	HOAC/H_2O-0.1NNaOH	Orange	Colorless	Colorless	0.4	Comm	LD50 1920 mg/Kg LD50 2420 mg/Kg

(a) DBN-1,5-Diazobicyclo [4.3.0] non-5-ene.
(b) DBU-1,5-Diazobicyclo [5.4.0] undu-5-ene
(c) Comm.-Commercial.
(d) Unk. - Unknown.
(e) LD50 - Lethal dose - 50 percent kill.
(f) LDLo - The lowest dose of a substance other than LD50 introduced by any route other than inhalation over any given period of time and reported to have caused death in man or the lowest dose introduced in one or more portions and reported to have caused death in animals.
(g) TDLo- The lowest dose of a substance, as published or made available to publish, introduced by any route other than inhalation over any given period of time and reported to produce any toxic effect in man or to produce carcenogenic, teratogenic, mutagenic or neoplustigenic effects in humans or animals.

TABLE A-3 SUMMARY OF PROPERTIES OF CANDIDATE REAGENTS FOR RDX

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
Zn-Sulfanilic acid/N(1-naphthyl)-ethylenediamine	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.[a]	LD50[b] ∿ 2g/kg/; LDLo[c] 150 mg/kg.
Zn-p-Chloroaniline/N(1-naphthyl)-ethylenediamine	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	LD50 300 mg/kg.; LDLo 150 mg/kg.
Zn-Procaine/N(1-naphthyl)-ethylenediamine	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	LD50 500 mg/kg.; LDLo 150 mg/kg.
Zn-2-Naphthylamine-6,8-disulfonic acid/N(1-naphthyl)ethylene-diamine	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	Unk.[d]; LDLo 150 mg/kg.
Zn-Sulfanilic acid/azulene	Benzene-H_2O/HOAC	Violet	Lt. Blue	Blue	0.4	Comm.	LD50 ∿ 2g/kg.; Unk.
Zn-p-Nitroaniline/azulene	Benzene-H_2O/HOAC	Blue-violet	Lt. Blue	Blue	0.4	Comm.	LD50 3249 mg/kg.; Unk.
Zn-p-Chloroaniline/azulene	Benzene-H_2O/HOAC	Violet	Lt. Blue	Blue	0.4	Comm.	LD50 300 mg/kg.; Unk.
Zn-p-Toluidine/azulene	Benzene-H_2O/HOAC	Blue-green	Lt. Blue	Blue	0.4	Comm.	LD50 1255 mg/kg.; Unk.
Zn-p-Anisidine/azulene	Benzene-H_2O/HOAC	Blue-green	Lt. Blue	Blue	0.4	Comm.	LD50 ∿ 500 mg/kg.; Unk.
Zn-N,N-dimethyl-p-phenylene-diamine/azulene	Benzene-H_2O/HOAC	Blue-green	Lt. Blue	Blue	0.4	Comm.	MLD ∿ 250 mg/kg.; Unk.
Zn-Procaine/azulene	Benzene-H_2O/HOAC	Red-violet	Lt. Blue	Blue	0.4	Comm.	LD50 500 mg/kg.; Unk.
Zn-Sulfanilic acid/N,N-dimethyl-1-naphthylamine	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 2g/kg.; LD50 ∿ 1400 mg/kg.
Zn-p-Chloroaniline/N,N-dimethyl-1-naphthylamine	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	LD50 300 mg/kg.; LD50 ∿ 1400 mg/kg.
Zn-Procaine/N,N-dimethyl-1-naphthylamine	Benzene-H_2O/HOAC	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 500 mg/kg.; LD50 ∿ 1400 mg/kg.

TABLE A-3 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
Zn-2-Naphthylamine-6,8-disulfonic acid/N,N-dimethyl-1-naphthylamine	Benzene-H_2O/HOAC	Blue-violet	Colorless	Colorless	0.4	Comm.	Unk.; LD50 ∿ 1400 mg/kg.
Zn-N,N,N',N'-Tetramethyl-p-phenylenediamine	HOAC	Blue	Lt. Blue	Lt. Blue	0.4	Comm.	LDLo ∿ 20 mg/kg.
Zn-Tetramethylbenzidine	HOAC	Yellow	Colorless	Straw	0.4	Comm.	Unk.
KOH-Sulfanilic acid/N(1-naphthyl)-ethylenediamine	H_2O-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 2g/kg.; LDLo 150 mg/kg.
Zn-p-aminoacetophenone/N(1-naphthyl)ethylenediamine	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; LDLo 150 mg/kg.
Zn-p-Aminoacetophenone/azulene	Benzene-HOAC	Violet	Lt. Blue	Blue	0.4	Comm.	LDLo 300 mg/kg.; Unk.
Zn-diaminodiphenylsulfone/azulene	Benzene-HOAC	Violet	Lt. Blue	Blue	0.4	Comm.	LD50 ∿ 100 mg/kg.; Unk.
$TiCl_3$-$FeCl_2$-p-dimethylamino-benzeldehyde	HCl-EtOH	Orange	Grey	Colorless	0.4	Comm.	LD50 620 mg/kg.
$TiCl_3$-p-dimethylaminobenzalde-hyde	HCl-EtOH	Orange	Grey	Colorless	0.4	Comm.	LD50 620 mg/kg.
Zn-1-Naphthylamine-7-sulfonic acid/N,N-Dimethyl-1-naph-thylamine	Benzene-H_2O/HOAC	Red-orange	Colorless	Colorless	0.4	Comm.	Unk. ; LD50 ∿ 1400 mg/kg.
Zn-Sulfanilic acid/1-naphthyl-amine-7-sulfonic acid	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 2g/kg.; Unk.
Zn-p-Aminobenzoic acid/N(1-naphthyl)ethylenediamine	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/kg.; LDLo 150 mg/kg.
Zn-4-Aminoacetophenone/N-Phenyl-2-naphthylamine	Benzene-H_2O/HOAC	Violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; LD50 1450 mg/kg.
Zn-Di-o-anisidine/m-phenylene-diamine	Benzene-H_2O/HOAC	Orange	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/kg.; LDLo 80 mg/kg.

TABLE A-3 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
Zn-Tolidine	Benzene-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 404 mg/kg.
Zn-Aminosalicylic acid/N(1-naphthyl)ethylenediamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 4g/kg.; LDLo 150 mg/kg.
Zn-m-Phenylenediamine	Benzene-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LDLo 80 mg/kg.
Zn-Diphenylamine	Benzene-H_2O-H_2SO_4	Violet	Colorless	Colorless	0.4	Comm.	LDLo ∿ 200 mg/kg.
Zn-Sulfanilic acid/m-phenylenediamine	Benzene-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 ∿ 2g/kg.; LDLo 80 mg/kg.
Zn-p-Aminobenzoic acid/N(1-naphthyl)ethylenediamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/kg.; LDLo 150 mg/kg.
Zn-4-Aminoacetophenone/N(1-naphthyl)ethylenediamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; LDLo 150 mg/kg.
Zn-Diaminodiphenylsulfone/N(1-naphthyl)ethylenediamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 100 mg/kg.; LDLo 150 mg/kg.
Zn-p-Aminobenzonitrile/N(1-naphthyl)ethylenediamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 150 mg/kg.
Zn-3-Aminobenzotrifluoride/N(1-naphthyl)ethylenediamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 150 mg/kg.
Zn-Sulfanilamide/N(1-naphthyl)-ethylenediamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/kg.; LDLo 150 mg/kg.
Zn-Di-o-anisidine/N,N-dimethyl-1-naphthylamine	Benzene-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/kg.; LD50 ∿ 1400 mg/kg.
Zn-4-Aminoacetophenone/N,N-Dimethyl-1-naphthylamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; LD50 ∿ 1400 mg/kg.
Zn-Diaminodiphenylsulfone/N,N-Dimethyl-1-naphthylamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 150 mg/kg.; LD50 ∿ 1400 mg/kg.
Zn-Anthranilic acid/N,N-Dimethyl-1-naphthylamine	Benzene-HOAC/H_2O	Blue	Colorless	Colorless	0.4	Comm.	$TDLo^{(e)}$ 4000 mg/kg.; LD50 ∿ 1400 mg/kg.

TABLE A-3 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
Zn-p-Aminobenzonitrile/N,N-Dimethyl-1-naphthylamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LD50 ∿ 1400 mg/kg.
Zn-3-Aminobenzotrifluoride/N,N-Dimethyl-1-naphthylamine	Benzene-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	Unk.; LD50 ∿ 1400 mg/kg.
Zn-5-Chloro-2-aminoanisole/N,N-Dimethyl-1-naphthylamine	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk.; LD50 ∿ 1400 mg/kg.
Zn-Di-o-anisidine/1-amino-7-naphthalinesulfonic acid	Benzene-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/kg.; Unk.
Zn-4-Aminoacetophenone/1-amino-7-naphthalinesulfonic acid	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; Unk.
Zn-p-Aminobenzoic acid/1- amino-7-naphthalenesulfonic acid	Benzene-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/kg.; Unk.
Zn-Diaminodiphenylsulfone/1-amino-7-naphthalenesulfonic acid	Benzene-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 100 mg/kg.; Unk.
Zn-p-Amino-benzonitrite/1-amino-7-naphthalene-sulfonic acid	Benzene-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	Unk.; Unk.
Zn-Sulfanilamide/1-amino-7-naphthalenesulfonic acid	Benzene-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/kg.; Unk.
Zn-Diaminodiphenylsulfone/N-phenyl-1-naphthylamine	Benzene-HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	LD50 2100 mg/kg.; Unk.
Zn-p-Aminobenzonitrile/N-Phenyl-1-naphthylamine	Benzene-HOAC/H_2O	Purple	Colorless	Colorless	0.4	Comm.	Unk.; Unk.
Zn-Sulfanilamide/N-phenyl-1-naphthylamine	Benzene-HOAC/H_2O	Blue-violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 3900 mg/kg.; Unk.
Zn-Sulfanilic acid/1-amino-5-naphthalenesulfonic acid	Benzene-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 2g/kg.; Unk.

TABLE A-3 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
Zn-Sulfanilamide/1-amino-5-naphthalenesulfonic acid	Benzene-HOAC H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/kg.; Unk.
Zn-Sulfanilamide/1,8-naphthalenediamine	Benzene-HOAC/ H_2O	Violet	Tan	Brown	0.4	Comm.	LD50 3900 mg/kg.; Unk.
Zn-1-Amino-4-chloro-3-toluene sulfonic acid/N(1-naphthyl)-ethylenediamine	Benzene-HOAC/ H_2O	Blue-violet	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 150 mg/kg.
Zn-1-Amino-4-chloro-3-toluene-sulfonic acid/1-amino-7-naphthelenesulfonic acid	Benzene-HOAC/ H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk.; Unk.
Zn-1-Amino-2,5-dichloro-4-benzene sulfonic acid/1-Amino-7-naphthalenesulfonic acid	Benzene-HOAC/ H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk.; Unk.
KOH-p-Chloroaniline /N(1-naphthyl)ethylenediamine	H_2O-HOAC/ H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 300 mg/kg.; LDLo 150 mg/kg.
KOH-Procaine/N(1-naphthyl) ethylenediamine	H_2O-HOAC/ H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 500 mg/kg.; LDLo 150 mg/kg.
KOH-Sulfanilic acid/azulene	H_2O-HOAC/H_2O	Pink	Blue	Blue	0.4	Comm.	LD50 2g/kg.; Unk.
KOH-Procaine/azulene	H_2O-HOAC/H_2O	Pink	Lt. Blue	Blue	0.4	Comm.	LD50 500 mg/kg.; Unk.
KOH-Sulfanilic acid/N,N-Dimethyl-1-naphthylamine	H_2O-HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	LD50 2g/kg.; LD50 ∿ 1400 mg/kg.
KOH-p-Nitroaniline/N,N-Dimethyl-1-naphthylamine	H_2O-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 3249 mg/kg.; LD50 ∿ 1400 mg/kg.
KOH-Procaine/N,N-Dimethyl-1-naphthylamine	H_2O-HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	LD50 500 mg/kg.; LD50 ∿ 1400 mg/kg.
KOH-N,N,N',N'-Tetramethyl-p-phenylenediamine	HOAC	Blue	Colorless	Colorless	0.4	Comm.	LDLo ∿ 20 mg/kg.

TABLE A-3 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
KOH-2-Naphthylamine-6,8-disulfonic acid/N(1-naphthyl)ethylenediamine	H_2O-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LDLo 150 mg/kg.
KOH-p-Phenylazoaniline/N(1-naphthyl)ethylenediamine	H_2O-HOAC/H_2O	Brown	Yellow	Red	0.4	Comm.	LDLo 1600 mg/kg.; LDLo 150 mg/kg.
KOH-4-Aminoacetophenone/N(1-naphthyl)ethylenediamine	H_2O-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; LDLo 150 mg/kg.
KOH-p-Nitroaniline/N-Phenyl-1-naphthylamine	H_2O-HOAC/H_2O	Brown	Lt. Yellow	Yellow	0.4	Comm.	LD50 3429 mg/kg.; Unk.
KOH-4-Aminoacetophenone/Azulene	H_2O-HOAC/H_2O	Orange	Lt. Blue	Blue	0.4	Comm.	LDLo 300 mg/kg.; Unk.
KOH-Diaminodiphenylsulfone/Azulene	H_2O-HOAC/H_2O	Orange	Lt. Blue	Blue	0.4	Comm.	LD50 ∿ 100 mg/kg.; Unk.
KOH-Dijulolidylmethane	H_2O-HOAC	Blue	Lt.Blue	Lt. Blue	0.4	Comm.	Unk.
KOH-m-Phenylenediamine	H_2O-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LDLo 80 mg/kg.
KOH-Sulfanilic acid/m-Phenylenediamine	H_2O-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 2g/kg.; LDLo 80 mg/kg.
KOH-1-Amino-7-naphthalenesulfonic acid/N(1-naphthyl) ethylenediamine	H_2O-HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 150 mg/kg.
KOH-1-Amino-7-naphthalenesulfonic acid/N,N-Dimethyl-1-naphthylamine	H_2O-HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	Unk.; LD50 ∿ 1400 mg/kg.
KOH-Sulfanilic acid/1-amino-7-naphthalenesulfonic acid	H_2O-HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	LD50 2g/kg.; Unk.
KOH-p-Aminobenzoic acid/N(1-naphthyl)ethylenediamine	H_2O-HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/kg.; LDLo 150 mg/kg.
KOH-4-Aminoacetophenone/N-Phenyl-2-naphthylamine	H_2O-HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; LD50 1450 mg/kg.

TABLE A-3 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
KOH-Di-o-anisidine/m-Phenylene-diamine	H_2O-HOAC/ H_2O	Brown	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/kg.; LDLo 80 mg/kg.
KOH-Sulfanilic acid/1-naphthol	H_2O-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 2g/kg.; LD50 2590 mg/kg.
KOH-p-Aminobenzoic acid/8-amino-1-naphthol-3,6-disulfonic acid	H_2O-HOAC/ H_2O	Violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/kg.; Unk.
KOH-Di-o-anisidine/2-naphthol	H_2O-HOAC/H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/kg.; LD50 2420 mg/kg.
KOH-Di-o-anisidine/N(1-naphthyl)-ethylenediamine	H_2O-HOAC/ H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/kg.; LDLo 150 mg/kg.
KOH-p-Aminobenzoic acid/N(1-naphthyl)ethylenediamine	H_2O-HOAC/ H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/kg.; LDLo 150 mg/kg.
KOH-4-Aminoacetophenone/N(1-naphthyl)ethylenediamine	H_2O-HOAC/ H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; LDLo 150 mg/kg.
KOH-Diaminodiphenylsulfone/ N(1-naphthyl)ethylenediamine	H_2O-HOAC/ H_2O	Pink	Colorless	Colorless	0.4	Comm.	LD50 ~ 100 mg/kg.; LDLo 150 mg/kg.
KOH-Anthranilic acid/N(1-naphthyl)ethylenediamine	H_2O-HOAC/ H_2O	Blue-violet	Colorless	Colorless	0.4	Comm.	TDLo 4000 mg/kg.; LDLo 150 mg/kg.
KOH-p-Aminobenzonitrile/ N(1-naphthyl)ethylenediamine	H_2O-HOAC/ H_2O	Pink	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 150 mg/kg.
KOH-3-Aminobenzotrifluoride/ N(1-naphthyl)ethylenediamine	H_2O-HOAC/ H_2O	Orange	Colorless	Colorless	0.4	Comm.	Unk.; LDLo 150 mg/kg.
KOH-Sulfanilamide/N(1-naphthyl)-ethylenediamine	H_2O-HOAC/ H_2O	Pink-violet	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/kg.; LDLo 150 mg/kg.
KOH-p-Aminobenzoic acid/N,N-Dimethyl-1-naphthylamine	H_2O-HOAC/ H_2O	Pink-violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/kg.; LD50 ~ 1400 mg/kg.

TABLE A-3 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
KOH-4-Aminoacetophenone/N,N-Dimethyl-1-naphthylamine	H_2O-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; LD50 ∿ 1400 mg/kg.
KOH-Diaminodiphenylsulfone/N,N-Dimethyl-1-naphthylamine	H_2O-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 100 mg/kg.; LD50 ∿ 1400 mg/kg
KOH-p-Aminobenzonitrile;N,N-Dimethyl-1-naphthylamine	H_2O-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	Unk.; LD50 ∿ 1400 mg/kg.
KOH-Sulfanilamide/N,N-Dimethyl-1-naphthylamine	H_2O-HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/kg.; LD50 ∿ 1400 mg/kg.
KOH-p-Aminobenzoic acid/1-Amino-7-naphthalenesulfonic acid	H_2O-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/kg.; Unk.
KOH-4-Aminoacetophenone/1-Amino-7-naphthalenesulfonic acid	H_2O-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; Unk.
KOH-Diamino-diphenylsulfone/1-Amino-7-naphthalenesulfonic acid	H_2O-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 ∿ 100 mg/kg.; Unk.
KOH-Anthranilic acid/1-Amino-7-naphthalenesulfonic acid	H_2O-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	TDLo 400 mg/kg.; Unk.
KOH-p-Aminobenzonitrile/1-Amino-7-naphthalenesulfonic acid	H_2O-HOAC/H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	Unk.; Unk.
KOH-3-Aminobenzotrifluoride/1-Amino-7-naphthalene sulfonic acid	H_2O-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk.; Unk.
KOH-5-Chloro-2-amino-anisole/1-Amino-7-naphthalene sulfonic acid	H_2O-HOAC/H_2O	Violet	Colorless	Colorless	0.4	Comm.	Unk.; Unk.
KOH-Sulfanilamide/1-Amino-7-naphthalene sulfonic acid	H_2O-HOAC/H_2O	Pink	Colorless	Colorless	0.4	Comm.	LD50 3900 mg/kg.; Unk.

TABLE A-3 (Continued)

REAGENT	SOLVENT	COLOR RESPONSE	BACKGROUND COLOR	REAGENT COLOR	SENSITIVITY, MICROGRAMS	REAGENT AVAILABILITY	TOXICITY OF REAGENT
KOH-Di-o-anisidine/N-Phenyl-1-naphthylamine	H_2O-HOAC/ H_2O	Orange	Colorless	Colorless	0.4	Comm.	LD50 1920 mg/kg.; Unk.
KOH-p-Aminobenzoic acid/N-Phenyl-1-naphthylamine	H_2O-HOAC/ H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 2000 mg/kg.; Unk.
KOH-4-Amino-acetophenone/N-Phenyl-1-naphthylamine	H_2O-HOAC/ H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LDLo 300 mg/kg.; Unk.
KOH-Diamino-diphenylsulfone/ N-Phenyl-1-naphthylamine	H_2O-HOAC/ H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	LD50 ~ 100 mg/kg.; Unk.
KOH-p-Aminobenzonitrile/N-Phenyl-1-naphthylamine	H_2O-HOAC/ H_2O	Red-violet	Colorless	Colorless	0.4	Comm.	Unk.; Unk.

(a) Comm. = Commercial.

(b) LD50 = Lethal dose - 50 percent kill.

(c) LDLo - Lethal Dose Low - the lowest dose of a substance other than LD50 introduced by any route ther than inhalation over any given period of time and reported to have caused death in man or the lowest single dose introduced in on or more divided portions and reported to have caused death in animals.

(d) Unk. = Unknown.

(e) TDLo - Toxic Dose Low - the lowest dose of a substance, as published or made available to publish, introduced by any route other than inhalation over any given period of time and reported to produce any toxic effect in man or to produce carcinogenic, teratogenic, mutagenic or neoplastigenic effects in humans or animals.

TABLE A-4 PROPERTIES OF THE TNT DETECTION SYSTEMS

Reagent	λ_{max} mu	Molar Absorbance ε	Solvent
1,5-Diazabicyclo[5.4.0]undec-5-ene	530	10,000	DMSO
Nitron	525-535	5,700	DMSO
1,5-Diazabicyclo[4.3.0]non-5-ene	535-545	9,100	DMSO
Bis(4-Dimethylaminophenyl)methane	505-530	38	DMSO
2,3,5,6-Tetramethyl-p-phenylenediamine	513-530	307	DMSO
Di-(9-Julolidyl)methane	510-528	76	DMSO
1,4-Diazabicyclo[2.2.2]octane	520-530	4,500	DMSO
1,8-Bis(dimethylamino)naphthalene	532	840	DMSO
3,4-Dimethoxyphenylacetonitrile-Et_4NOH	503-513 458-465	5,910 6,140	EtOH
Benzylacetone-Et_4NOH	468 505	6,360 5,910	EtOH
3-Methyl-2-hexanone-Et_4NOH	500-512	5,910	EtOH
Phenyl-2-propanone-Et_4NOH	508	5,910	EtOH
4-Chlorophenylacetonitrile-Et_4NOH	512	17,270	EtOH
Phenylacetonitrile-Et_4NOH	505-515	11,140	EtOH
p-Methoxyphenylacetonitrile-Et_4NOH	508-515 460	6,820 7,955	EtOH
1,3-Diphenylacetone-Et_4NOH	500	32,270	EtOH
5-Hexene-2-one-Et_4NOH	468	6,365	EtOH
1-Phenyl-2-butanone-Et_4NOH	510	6,590	EtOH
4,4-Dimethoxy-2-butanone-Et_4NOH	575-505	2,955	EtOH
Propiophenone-Et_4NOH	465	6,820	EtOH
Cyclohexanone-Et_4NOH	515 465	10,230 8,410	EtOH

TABLE A-4 (Continued

Reagent	λ_{max} mu	Molar Absorbance ϵ	Solvent
1,3-Dicarbomethoxyacetone-Et_4NOH	495-500	1,000	EtOH
Cholestan-3-one-Et_4NOH	505	4,775	EtOH
Progesterone-Et_4NOH	438 490	5,170 5,055	EtOH
17-Methylestosterone-Et_4NOH	492-505 438	3,410 3,070	EtOH
Pregnenlone-Et_4NOH	495-505 435	3,600 3,410	EtOH
Testosterone-Et_4NOH	500-510 437	2,615 2,045	EtOH
$TiCl_3$-Diphenylacrolein	460[a]	40	EtOH
$TiCl_3$-Dimethylaminobenzaldehyde	460[a]	60	EtOH
$TiCl_3$-4-Dimethylaminocinnamaldehyde	550	1,230	EtOH
$TiCl_3$-N(4-Pyridyl)pyridinium chloride	490[b]	1,250	EtOH
$SnCl_2$-2-Hydroxy-1-naphthaldehyde	460[a]	85	EtOH
$SnCl_2$-2-Chloro-4-dimethylamino-benzaldehyde	460[a]	75	EtOH
$SnCl_2$-2-Methyl-4-dimethylamino-benzaldehyde	460[a]	85	EtOH
$SnCl_2$-Vanillin	460[a]	75	EtOH
$SnCl_2$-N(4-Pyridyl)pyridinium chloride	490[b]	1,590	EtOH
$SnCl_2$-2-Bromo-4-dimethylamino-benzaldehyde	460[a]	45	EtOH
$SnCl_2$-2-Phenoxy-4-dimethylamino-benzaldehyde	460[a]	60	EtOH
$SnCl_2$-4-Dimethylaminocinnamaldehyde	520	45	EtOH
$SnCl_2$-2,5-Dimethoxy-4-dimethylamino-benzaldehyde	460[a]	60	EtOH
$SnCl_2$-Diphenylacrolein	460[a]	50	EtOH

TABLE A-4 (Continued)

Reagent	λ_{max} mu	Molar Absorbance ε	Solvent
$SnCl_2$-4-Dimethylaminobenzaldehyde	460[(a)]	160	EtOH
$SnCl_2$-4-Diphenylaminobenzaldehyde	460[(a)]	60	EtOH
p-Nitrosodimethylaniline	422	11,025	EtOH
KOH-Methylcellosolve	505-535	8,409	Methylcellosolve

(a) No absorption peak was evident in this spectra but since the solution was yellow the absorbance was taken at 460 mu, the middle of the yellow absorption band.

(b) No absorption peak was evident in this spectra but since the solution was orange the absorbance was taken at 490 mu, the middle of the orange absorption band.

TABLE A-5 EVALUATION OF TNT REAGENTS

Reagent	1st Determination λ_{max}(mu)		2nd Determination λ_{max}(mu)	
1,5-Diazabicyclo[5.4.0]undec-5-ene	530	10,000	510-515	4,430
1,5-Diazabicyclo[4.3.0]non-5-ene	535-545	9,100	505-515	3,520
4-Chlorophenylacetonitrile-Et_4NOH	512	17,270	512	16,590
Phenylacetonitrile-Et_4NOH	505-515	11,140	510-515	15,000
1,3-Diphenylacetone-Et_4NOH	500	32,270	503	22,272
Cyclohexanone-Et_4NOH	515	10,230	515	15,000
Cyclopentanone-Et_4NOH	511	10,445	512	22,272
Nitromethane-Et_4NOH	505	28,510	505	20,000
Fluorene-Et_4NOH	500	11,500	520	6,705
Ethylenediamine	523-530	9,090	530	9,770
KOH-Methylcellosolve	505-535	8,409	505-510	5,227

TABLE A-6 STORAGE TESTS ON TNT REAGENTS

Reagent	Initial Color	Limit (b) µg	7 Days Color	7 Days Limit µg	14 Days Color	14 Days Limit µg	21 Days Color	21 Days Limit µg	28 Days Color	28 Days Limit µg	35 Days Color	35 Days Limit µg
1,3-Dimethyl-acetone (a)	Yellow	0.4	Yellow	0.4	Yel-org	0.4	Yel-org	0.4	Yel-org	0.4	Yel-org	0.4
Cyclo-pentanone (a)	Straw	0.4	Orange	0.4	Org-brown	0.4	Org-brown	0.4	Org-brown	0.4	Org-brown	0.4
Nitro-methane (a)	Colorless	0.4	Orange	0.4	Org-brown	0.4	Org-brown	0.4	Org-brown	0.4	Org-brown	0.4

(a) All reagents consisted of 100 ml EtOH, 4 ml 20 % Me_4NOH in MeOH and 5 g ketone or nitromethane.

(b) Using PETN.

TABLE A-7 EVALUATION OF TNT REAGENT ON VARIOUS SUBSTRATES[a]

Substrate	Color	Composition	Detection Limit, µg	Remarks
Papers				
20 lb bond	White	100% cotton	0.4	
16 lb bond	Yellow	--	0.4	
Onion skin	White	25% cotton	0.4	
Plain, long grain	White	--	0.4	
Index card	White	--	0.4	
File folder	Straw	--	0.4	
File packet, glazed	Dk brown	--	4	
File folder, glazed	Med brown	--	0.4	
Blotter paper	White	--	0.4	
Xerox copy paper, coated	White	--	0.4	
Construction paper	White	--	0.4	
Notebook filler	White	--	0.4	
Legal pad	Yellow	--	0.4	
Grocery bag	Brown	--	4.0	
Wrapping paper	Brown	--	0.4	
Envelopes				
Letterhead Bond	White	--	0.4	
Airmail	White/blue	--	0.4	
Business	White	--	0.4	
Clasp envelope	Lt brown	--	0.4	
Clasp envelope, glazed	Med brown	--	0.4	
Utility shipping bag	Med brown	--	0.4	
Styrdite shipping bag	Med brown	--	0.4	

TABLE A-7 (Continued)

Substrate	Color	Composition	Detection Limit, μg	Remarks
Cardboard				
Posterboard	White	--	0.4	
Lightweight cardboard	Gray	--	0.4	
Medium weight box-board	Brown	--	0.4	
Corrugated, coated	White	--	0.4	
Corrugated	Brown	--	4.0	
Miscellaneous				
Accohyde	Cream	Vinyl	0.4	
Polyethylene sheet	Clear	Polyethylene	0.4	
Wood	Tan	--	4.0	
Leather, vegetable tanned	Med-brown	Calfskin	>120	
Cloth	White	Cotton	0.4	
Foam	White	Polyurethane	0.4	

(a) Reagent consisted of 5 g cyclopentanone, 5 ml Et_4NOH in water and 100 ml ethanol.

TABLE A-8 EVALUATION OF NITRATE ESTER REAGENTS

Reagent	λ max	ε	Solvent
p-Aminobenzoic acid N(1-Naphthyl)ethylenediamine	555	36,666	HOAc-H_2O
4-Aminosalicylic acid N(1-Naphthyl)ethylenediamine	550	27,333	HOAc-H_2O
4-Aminoacetophenone N-Phenyl-2-naphthylamine	515-525	12,500	HOAc-H_2O
o-Dianisidine m-Phenylenediamine	455	25,500	HOAc-H_2O
1-Aminopyrene	435 (yel-green)	5,417	HOAc-H_2O
Sulfanilic acid m-Phenylenediamine	453	19,778	HOAc-H_2O
N,N-Diphenyl-p-phenylenediamine	520	8,667	HOAc-H_2O
Indole	465 (yellow)	1,000	HOAc-H_2O
p-Chloroaniline N,N-Dimethyl-1-naphthylamine	550	14,333	HOAc-H_2O
2-Naphthylamine-6,8-disulfonic acid N,N-Dimethyl-1-naphthylamine	558	5,500	HOAc-H_2O
N,N,N',N'-Tetramethyl-p-phenylenediamine	618 565	70,000	HOAc-H_2O
o-Tolidine	440	16,500	HOAc-H_2O
Procaine N,N-Dimethyl-1-naphthylamine	530-535	42,333	HOAc-H_2O
Sulfanilic acid N,N-Dimethyl-1-naphthylamine	543	21,667	HOAc-H_2O
p-Nitroaniline N,N-Dimethyl-1-naphthylamine	528	45,333	HOAc-H_2O

TABLE A-8 (Continued)

Reagent	λ_{max}	ε	Solvent
Tetramethylbenzidine	470	7,833	HOAc -H_2O
m-Phenylenediamine	450	16,444	HOAc -H_2O
1-Amino-7-naphthalenesulfonic acid N(1-Naphthyl)ethylenediamine	560	7,833	HOAc -H_2O
Sulfanilic acid N(1-Naphthyl)ethylenediamine	550	33,333	HOAc -H_2O
p-Nitroaniline N(1-Naphthyl)ethylenediamine	545	28,333	HOAc -H_2O
Procaine N(1-Naphthyl)ethylenediamine	550	30,667	HOAc -H_2O
2-Naphthylamine-6,8-disulfonic acid N(1-Naphthyl)-ethylenediamine	550	5,333	HOAc -H_2O
p-Toluidine N(1-Naphthyl)ethylenediamine	570	11,667	HOAc -H_2O
p-Chloraniline N(1-Naphtyl)ethylenediamine	560	22,000	HOAc -H_2O
p-Aminobenzonitrile N(1-Naphthyl)ethylenediamine	544	40,667	HOAc -H_2O
p-Phenylazoaniline N(1-Naphthyl)ethylenediamine	498	175,000	HOAc -H_2O
Diaminodiphenyl sulfone N(1-Naphthyl)ethylenediamine	550	34,000	HOAc -H_2O
2-Ethoxy-3,6-Diaminoacridine N(1-Naphthyl)ethylenediamine	553	10,167	HOAc -H_2O
3-Aminobenzotrifluoride N(1-Naphthyl)ethylenediamine	542	26,333	HOAc -H_2O
Diaminodiphenylsulfone N,N-Dimethyl-1-Naphthylamine	532	39,000	HOAc -H_2O
4-Amino-6-Chloro-m-benzenedisulfonamide N(1-Naphthyl)ethylenediamine	480	233	HOAc -H_2O

TABLE A-8 (Continued)

Reagent	λ_{max}	ϵ	Solvent
p-Aminoacetophenone N,N-Dimethyl-1-naphthylamine	538	43,000	HOAc-H_2O
p-Aminobenzonitrile N,N-Dimethyl-1-Naphthylamine	528	38,333	HOAc-H_2O
p-Aminobenzoic acid N,N-Dimethyl-1-Naphthylamine	535	47,333	HOAc-H_2O
Sulfanilamide N(1-Naphthyl)ethylenediamine	544	33,000	HOAc-H_2O
Sulfanilamide 1-Amino-7-Naphthalenesulfonic acid	524	44,667	HOAc-H_2O
4-Aminoacetophenone 1-Amino-7-Naphthalenesulfonic acid	530	17,333	HOAc-H_2O
3-Aminobenzotrifluoride 1-Amino-7-Naphthalenesulfonic acid	521	15,000	HOAc-H_2O
p-Aminobenzonitrile 1-Amino-7-Naphthalenesulfonic acid	520	18,667	HOAc-H_2O
Diaminodiphenyl Sulfone 1-Amino-7-Naphthalenesulfonic acid	528	39,333	HOAc-H_2O
p-Aminobenzoic acid 1-Amino-7-Naphthalenesulfonic acid	529	24,333	HOAc-H_2O
Sulfanilamide N,N-Dimethyl-1-Naphthylamine	529	36,667	HOAc-H_2O
3-Aminobenzotrifluoride N,N-Dimethyl-1-Naphthylamine	532	25,667	HOAc-H_2O
Sulfanilic acid N-Phenyl-1-Naphthylamine	565	2,333	HOAc-H_2O
p-Aminobenzonitrile N-Phenyl-1-Naphthylamine	556	40,333	HOAc-H_2O
4-Aminoacetophenone N-Phenyl-1-Naphthylamine	565	43,000	HOAc-H_2O

TABLE A-8 (Continued)

Reagent	λ_{max}	ε	Solvent
p-Aminobenzoic acid N-Phenyl-1-Naphthylamine	563	41,667	HOAc-H_2O
1-Amino-4-Chloro-3-Toluenesulfonic acid 1-Amino-7-Naphthalenesulfonic acid	535	28,667	HOAc-H_2O
1-Amino-4-Chloro-3-Toluenesulfonic acid 1,8-Naphthalenediamine	548	9,333	HOAc-H_2O
1-Amino-4-Chloro-3-Toluenesulfonic acid N(1-Naphthyl)ethylenediamine	552	8,000	HOAc-H_2O
Sulfanilamide 1,8-Naphthalenediamine	544	17,000	HOAc-H_2O
Sulfanilic acid 1,8-Naphthalenediamine	550	9,000	HOAc-H_2O
Diaminodiphenylsulfone N-Phenyl-2-Naphthylamine	518	8,333	HOAc-H_2O
Di-o-Anisidine 1-Amino-7-Naphthalenesulfonic acid	564	14,333	HOAc-H_2O
4-Aminoacetophenone N(1-Naphthyl)ethylenediamine	552	31,333	HOAc-H_2O
1-Amino-2,5-Dichloro-4-Benzenesulfonic acid 1-Amino-7-Naphthalenesulfonic acid	540	31,333	HOAc-H_2O
1-Amino-2,5-Benzenedisulfonic acid 1,8-Naphthalenediamine	544	13,333	HOAc-H_2O
Sulfanilic acid 1-Amino-7-Naphthalenesulfonic acid	531	40,000	HOAc-H_2O
4-Aminoacetophenone N-Phenyl-2-Naphthylamine	519	18,000	HOAc-H_2O
Sulfanilic acid N,N-Diethylaniline	511	11,000	HOAc-H_2O
Di-o-Anisidine N(1-Naphthyl)ethylenediamine	598	10,333	HOAc-H_2O

TABLE A-8 (Continued)

Reagent	λ_{max}	ε	Solvent
5-Chloro-2-Aminoanisole 1-Amino-7-Naphthalenesulfonic acid	548	33,667	HOAc-H_2O
Diaminodiphenylsulfone 1-Amino-7-Naphthalenesulfonic acid	528	44,000	HOAc-H_2O
Sulfanilamide 1-Amino-7-Naphthalenesulfonic acid	523	51,333	HOAc-H_2O
p-Aminobenzoic acid N-Phenyl-1-Naphthylamine	564	49,667	HOAc-H_2O
Diaminodiphenylsulfone N-Phenyl-1-Naphthylamine	566	47,000	HOAc-H_2O
Sulfanilamide N-Phenyl-1-Naphthylamine	558	46,333	HOAc-H_2O
Di-julolidino-methane	636	193,333	HOAc-H_2O
Di-o-Anisidine 2-Naphthol	481	6,667	0.1 NaOH- HOAc-H_2O
Sulfanilic acid Phenol	348	4,433	0.1 NaOH- HOAc-H_2O
2,6-bis(dimethylamino)anthracene	469	2,667	HOAc-H_2O
	520	433,333	HOAc-H_2O
4,4',4' Methylidynetris(N,N-dimethylaniline	590	17,000	HOAc-H_2O
α,α-bis(p-dimethylaminophenyl)-2-methoxy-p-cresol	608	10,667	HOAc-H_2O
4-chloro-α,α-bis(p-dimethylaminophenyl)-o-cresol	630	8,333	HOAc-H_2O
4,4'(2-Thenylidene)bis(N,N-dimethylaniline)	628 379	5,333 25,667	HOAc-H_2O

TABLE A-8 (Continued)

Reagent	λ_{max}	ε	Solvent
α,α-bis(p-dimethylaminophenyl)-p-cresol	607 459	21,667 8,333	HOAc-H_2O
α,α-b(p-dimethylaminophenyl)-6-methoxy-m-toluenesulfonic sodium salt	618 448	10,833 4,500	HOAc-H_2O
Anthranilic acid N(1-Naphthyl)ethylenediamine	558	19,333	HOAc-H_2O

TABLE A-9 EVALUATION OF NITRATE ESTER REAGENTS FOR REPRODUCIBILITY

Reagent	1st Evaluation λ_{max}	1st Evaluation ϵ	2nd Evaluation λ_{max}	2nd Evaluation ϵ
1-Amino-7-Naphthalenesulfonic Acid N-N-Dimethyl-1-Napthylamine	548	24,100	547	24,770
Sulfanilamide N-Phenyl-1-Napthylamine	555	43,970	556	44,830
p-Nitroaniline N-Phenyl-1-Naphthylamine	558	31,370	557	33,033
p-Aminobenzoic Acid 8-Amino-1-Naphthol-3,6-disulfonic Acid	537	30,500	536	25,570
p-Aminobenzonitrile N-Phenyl-1-Naphthylamine	557	50,300	557	49,830
p-Aminobenzoic Acid N(1-Naphthyl)ethylenediamine	555	36,670	553	32,670
4-Aminosalicylic Acid N(1-Naphthyl)ethylenediamine	550	27,300	550	27,870
Procaine N,N-Dimethyl-1-naphthylamine	530-535	42,330	533	45,770
p-Nitroaniline N,N-Dimethyl-1-naphthylamine	528	45,300	527	45,830
Sulfanilic Acid N(1-Naphthyl)ethylenediamine	550	33,300	552	19,900
p-Nitroaniline N-(1-Naphthyl)ethylenediamine	545	28,000	547	25,430
Procaine N(1-Naphthyl)ethylenediamine	550	30,670	548	22,170
p-Aminobenzonitrile N(1-Naphthyl)ethylenediamine	544	40,670	544	32,530
Diaminodiphenylsulfone N(1-Naphthyl)ethylenediamine	550	34,000	534	39,200
m-Aminobenzontrifluoride N(1-Naphthyl)ethylenediamine	542	26,330	543	19,270
Diaminodiphenylsulfone N,N-Dimethyl-1-naphthylamine	532	39,000	533	39,400

TABLE A-9 (Continued)

Reagent	1st Evaluation λ_{max}	1st Evaluation ϵ	2nd Evaluation λ_{max}	2nd Evaluation ϵ
p-Aminoacetophenone N, N-Dimethyl-1-naphthylamine	538	43,000	539	41,900
p-Aminobenzonitrile N,N-Dimethyl-1-naphthylamine	528	38,000	527	38,900
p-Aminobenzoic Acid N,N-Dimethyl-1-naphthylamine	535	47,000	539	39,270
Sulfanilamide N(1-Naphthyl)ethylenediamine	544	33,000	545	27,400
Sulfanilamide 1-Amino-7-naphthalensulfonic Acid	524	44,700	526	44,300
Diaminodiphenylsulfone 1-Amino-7-naphthalenesulfonic Acid	528	39,000	528	43,700
Sulfanilamide N,N-Dimethyl-1-naphthylamine	529	36,700	529	37,633
p-Aminobenzonitrile N-Phenyl-1-naphthylamine	556	40,300	556	49,230
p-Aminoacetophenone N-Phenyl-1-naphthylamine	565	43,000	568	52,170
p-Aminobenzoic Acid N-Phenyl-1-naphthylamine	563	41,700	565	50,970
1-Amino-4-chloro-3-toluenesulfonic Acid 1-Amino-7-naphthalenesulfonic Acid	535	28,700	538	35,833
4-Aminoacetophenone N(1-Naphthyl)ethylenediamine	552	31,300	555	34,100
1-Amino-2,5-dichloro-4-benzenesulfonic Acid 1-Amino-7-naphthalenesulfonic Acid	540	31,300	511	35,630
Sulfanilic Acid 1-Amino-7-naphthalenesulfonic Acid	531	40,000	533	41,570
5-Chloro-2-aminoanisole 1-Amino-7-naphthalenesulfonic Acid	548	33,700	549	32,000
Diaminodiphenylsulfone 1-Amino-7-naphthalenesulfonic Acid	528	44,000	528	44,130

TABLE A-9 (Continued)

Reagent	1st Evaluation λ_{max}		2nd Evaluation λ_{max}	ϵ
Sulfanilamide 1-Amino-7-naphthalenesulfonic Acid	523	51,300	525	44,270
p-Aminobenzoic Acid N-Phenyl-1-naphthylamine	564	49,700	564	51,970
Diaminodiphenylsulfone N-Phenyl-1-naphthylamine	566	47,000	562	51,633
Sulfanilamide N-Phenyl-1-naphthylamine	558	46,300	565	49,467

TABLE A-10 STORAGE TESTS OF NITRATE ESTER REAGENTS[a,b]

Reagent	Initial		7 Days		14 Days		21 Days		28 Days		35 Days	
	Color	Limit	Color	Limit	Color	Limit	Color	Limit	Color	Limit	Color	Limit
p-Aminobenzoic acid N-Phenyl-1-naphthylamine	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4
p-Aminoacetophenone N-Phenyl-1-naphthylamine	Straw	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4
Diaminodiphenylsulfone N-Phenyl-1-naphthylamine	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4
p-Aminobenzonitrile N-Phenyl-1-naphthylamine	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Pink-brown	0.4	Pink-brown	0.4	Brown-pink	0.4
Procaine N,N-Dimethyl-1-naphthylamine	Colorless	0.4	V lt pink	0.4	V lt pink	0.4	V lt pink	0.4	V lt pink	0.4	V lt pink	0.4
Sulfanilamide N-Phenyl-1-naphthylamine	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4

(a) All reagents consisted of 0.5 g of each of the primary amine and coupling agent in 150 ml 50/50 HOAc/H_2O.

(b) PETN used as nitrate ester.

TABLE A-11 EVALUATION OF NITRATE ESTER REAGENTS ON VARIOUS SUBSTRATES[a,b]

Substrate	Color	Composition	Detection Limit, μg	Remarks
Papers				
20# Bond	White	100% cotton	0.4	
16# Bond	Yellow		0.4	
Onion skin	White	25% cotton	0.4	
Plain long grain	White		0.4	
Index card	White		0.4	
File folder	Straw		0.4	
File packet, glazed	Dk.brown		>100	
File folder, glazed	Med.brown		4.0	
Blotter paper	White		0.4	
Xerox copy paper, coated	White		4.0	
Construction paper	White		0.4	
Notebook folder	White		0.4	
Legal pad	Yellow		0.4	
Grocery bag	Brown		>100	
Wrapping paper	Brown		40	
Envelopes				
Letterhead bond	White		0.4	
Airmail	White/blue		0.4	
Business	White		0.4	
#10 Airmail	White		0.4	
Clasp envelope	Lt.brown		4.0	Weak positive response to glue
Clasp envelope, glazed	Med.brown		>100	
Utility shipping bag	Med.brown		4.0	
Styrdite shipping bag	Med.brown		40.0	

TABLE A-11 (Continued)

Substrate	Color	Composition	Detection Limit, μg	Remarks
Cardboards				
Posterboard	White		0.4	
Lightweight cardboard	Gray		4.0	
Medium weight box board	Brown		4.0	
Corrugated, coated	White		0.4	
Corrugated	Brown		4.0	
Miscellaneous				
Accohyde	Cream	Vinyl	0.4	Color faded
Polyethylene sheet	Clear	Polyethylene	0.4	Color faded
Wood	Tan	Pine	4.0	
Leather, vegetable tanned	Med.brown	Calfskin	--	Leather turned dark and brittle
Cloth	White	Cotton	0.4	
Foam	White	Polyurethane	0.4	

(a) Stock solutions of PETN (pentaerythritol tetranitrate) used to spot the substrates.

(b) Substrate sprayed first with a suspension of 10 g zinc dust in benzene followed by a solution of 0.3 g procaine and 0.3 g N,N-dimethyl-1-naphthylamine in 100 ml 50/50 HoAc/EtOH.

TABLE A-12 EVALUATION OF RDX REAGENTS

Reagent	λ_{max}	ϵ	Solvent
p-Aminobenzoic acid N(1-naphthyl)ethylenediamine	555	36,666	HOAc-H_2O
Aminosalicylic acid N(1-naphthyl)ethylenediamine	550	27,333	HOAc-H_2O
4-Aminoacetophenone N-Phenyl-2-naphthylamine	515-525	12,500	HOAc-H_2O
Di-o-anisidine m-Phenylenediamine	455	25,500	HOAc-H_2O
Sulfanilic acid m-Phenylenediamine	453	19,778	HOAc-H_2O
p-Chloroaniline N,N-Dimethyl-naphthylamine	550	14,333	HOAc-H_2O
2-Naphthylamine-6,8-disulfonic acid N,N-Dimethyl-1-naphthylamine	558	5,500	HOAc-H_2O
N,N,N',N'-Tetramethyl-p-phenylenediamine	618	70,000	HOAc-H_2O
o-Tolidine	440	16,500	HOAc-H_2O
Procaine N,N-Dimethyl-1-naphthylamine	530-535	42,333	HOAc-H_2O
Sulfanilic acid N,N-Dimethyl-1-naphthylamine	543	21,667	HOAc-H_2O
Tetramethylbenzidine	470	7,833	HOAc-H_2O
m-Phenylenediamine	450	16,444	HOAc-H_2O
1-Amino-7-naphthalenesulfonic acid N(1-naphthyl)ethylenediamine	560	7,833	HOAc-H_2O
Sulfanilic acid N(1-naphthyl)ethylenediamine	550	33,333	HOAc-H_2O
p-Nitroaniline N,N-Dimethyl-1-naphthylamine	528	45,333	HOAc-H_2O
Procaine N(1-naphthyl)ethylenediamine	550	30,667	HOAc-H_2O

TABLE A-12 (Continued)

Reagent	λ_{max}	ϵ	Solvent
2-Naphthylamine-6,8-disulfonic acid N(1-naphthyl)ethylenediamine	550	5,333	HOAc-H_2O
p-Chloroaniline N(1-naphthyl)ethylenediamine	560	22,000	HOAc-H_2O
p-Aminobenzonitrile N(1-naphthyl)ethylenediamine	544	40,667	HOAc-H_2O
p-Phenylazoaniline N(1-naphthyl)ethylenediamine	498	175,000	HOAc-H_2O
Diaminodiphenylsulfone N(1-naphthyl)ethylenediamine	550	34,000	HOAc-H_2O
Anthranilic acid N(1-naphthyl)ethylenediamine	558	19,333	HOAc-H_2O
3-Aminobenzotrifluoride N(1-naphthyl)ethylenediamine	542	26,333	HOAc-H_2O
Diaminodiphenylsulfone N,N-Dimethyl-1-naphthylamine	532	39,000	HOAc-H_2O
4-Aminoacetophenone N,N-Dimethyl-1-naphthylamine	538	43,000	HOAc-H_2O
p-Aminobenzonitrile N,N-Dimethyl-1-naphthylamine	528	38,333	HOAc-H_2O
p-Aminobenzoic acid N,N-Dimethyl-1-naphthylamine	535	47,333	HOAc-H_2O
Sulfanilamide N(1-naphthyl)ethylenediamine	544	33,000	HOAc-H_2O
4-Aminoacetophenone 1-Amino-7-naphthalenesulfonic acid	530	17,333	HOAc-H_2O
3-Aminobenzotrifluoride 1-Amino-7-naphthalenesulfonic acid	521	15,000	HOAc-H_2O
p-Aminobenzonitrile 1-Amino-7-naphthalenesulfonic acid	520	18,667	HOAc-H_2O
Diaminodiphenylsulfone 1-Amino-7-naphthalenesulfonic acid	528	39,333	HOAc-H_2O

TABLE A-12 (Continued)

Reagent	λ_{max}	ϵ	Solvent
p-Aminobenzoic acid 1-Amino-7-naphthalenesulfonic acid	529	24,333	HOAc-H_2O
Sulfanilamide N,N-Dimethyl-1-naphthylamine	529	36,667	HOAc-H_2O
3-Aminobenzotrifluoride N,N-Dimethyl-1-naphthylamine	532	25,667	HOAc-H_2O
p-Aminobenzonitrile N-Phenyl-1-naphthylamine	556	40,333	HOAc-H_2O
4-Aminoacetophenone N-Phenyl-1-naphthylamine	565	43,000	HOAc-H_2O
p-Aminobenzoic acid N-Phenyl-1-naphthylamine	563	41,667	HOAc-H_2O
1-Amino-4-chloro-3-toluenesulfonic acid 1-Amino-7-naphthalenesulfonic acid	535	28,667	HOAc-H_2O
1-Amino-4-chloro-3-toluenesulfonic acid N(1-naphthyl)ethylenediamine	552	8,000	HOAc-H_2O
Sulfanilamide 1,8-Naphthalenediamine	544	17,000	HOAc-H_2O
Di-o-anisidine 1-Amino-7-naphthalenesulfonic acid	564	14,333	HOAc-H_2O
p-Aminoacetophenone N(1-naphthyl)ethylenediamine	552	31,333	HOAc-H_2O
1-Amino-2,5-dichloro-4-benzenesulfonic acid 1-Amino-7-naphthalenesulfonic acid	540	31,333	HOAc-H_2O
Sulfanilic acid 1-Naphthylamine-7-sulfonic acid	531	40,000	HOAc-H_2O
Di-o-anisidine N(1-naphthyl)ethylenediamine	598	10,333	HOAc-H_2O
5-Chloro-2-aminoanisole 1-Amino-7-naphthalenesulfonic acid	548	33,667	HOAc-H_2O
Sulfanilamide 1-Amino-7-naphthalenesulfonic acid	523	51,333	HOAc-H_2O

TABLE A-12 (Continued)

Reagent	λ_{max}	ϵ	Solvent
Diaminodiphenylsulfone N-Phenyl-1-naphthylamine	566	47,000	HOAc-H_2O
Dijulolidylmethane	636	193,333	HOAc-H_2O
Di-o-anisidine 2-naphthol	481	6,667	NaOH:HOAc-H_2O
1-Amino-7-naphthalenesulfonic acid N,N-dimethyl-1-naphthylamine	548	24,100	HOAc-H_2O
Di-o-anisidine N,N-dimethyl-1-naphthylamine	544	8,300	HOAc-H_2O
Anthranilic acid N,N-dimethyl-1-naphthylamine	541	4,333	HOAc-H_2O
Diphenylamine	no visible		
5-Chloro-2-aminoanisole N,N-dimethyl-1-naphthylamine	553	8,967	HOAc-H_2O
Sulfanilimide N-phenyl-1-naphthylamine	555	43,967	HOAc-H_2O
p-Nitroaniline 1-Amino-5-naphthalenesulfonic acid	540	10,500	HOAc-H_2O
Sulfanilimide 1-Amino-5-naphthalenesulfonic acid	526	13,133	HOAc-H_2O
p-Nitroaniline N-phenyl-1-naphthylamine	558	31,367	HOAc-H_2O
Sulfanilic acid 1-Amino-7-naphthalenesulfonic acid	538	19,100	HOAc-H_2O
4-Aminoacetophenone N-Phenyl-2-naphthylamine	518	18,533	HOAc-H_2O
p-Aminobenzoic acid 8-Amino-1-naphthol-3,6-disulfonic acid	537	30,500	HOAc-H_2O
Anthranilic acid 1-Amino-7-naphthalenesulfonic acid	538	14,833	HOAc-H_2O

TABLE A-12 (Continued)

Reagene	λ_{max}	ϵ	Solvent
Di-o-anisidine N-Phenyl-1-naphthylamine	612	21,367	HOAc-H_2O
p-Aminobenzonitrile N-Phenyl-1-naphthylamine	557	50,300	HOAc-H_2O

TABLE A-13 EVALUATION OF RDX AND NITRATE ESTER REAGENTS

Reagent	1st Evaluation		2nd Evaluation	
	λ_{max}	ε	λ_{max}	ε
1-Amino-7-Naphthalenesulfonic Acid N-N-Dimethyl-1-Naphthylamine	548	24,100	547	24,770
Sulfanilamide N-Phenyl-1-Naphthylamine	555	43,970	556	44,830
p-Nitroaniline N-Phenyl-1-Naphthylamine	558	31,370	557	33,033
p-Aminobenzoic Acid 8-Amino-1-Naphthol-3,6-disulfonic acid	537	30,500	536	25,570
p-Aminobenzonitrile N-Phenyl-1-Naphthylamine	557	50,300	557	49,830
p-Aminobenzoic Acid N(1-Naphthyl)ethylenediamine	555	36,670	553	32,670
4-Aminosalicylic Acid N(1-Naphthyl)ethylenediamine	550	27,300	550	27,870
Procaine N,N-Dimethyl-1-naphthylamine	530-535	42,330	533	45,770
p-Nitroaniline N,N-Dimethyl-1 naphthylamine	528	45,300	527	45,830
Sulfanilic Acid N(1-Naphthyl)ethylenediamine	550	33,300	552	19,900
p-Nitroaniline N(1-Naphthyl)ethylenediamine	545	28,000	547	25,430
Procaine N(1-Naphthyl)ethylenediamine	550	30,670	548	22,170
p-Aminobenzonitrile N(1-Naphthyl)ethylenediamine	544	40,670	544	32,530
Diaminodiphenylsulfone N(1-Naphthyl)ethylenediamine	550	34,000	534	39,200
m-Aminobenzotrifluoride N(1-Naphthyl)ethylenediamine	542	26,330	543	19,270
Diaminodiphenylsulfone N,N-Dimethyl-1-naphthylamine	532	39,000	533	39,400

TABLE A-13 (Continued)

Reagent	1st Evaluation λ_{max}	1st Evaluation ϵ	2nd Evaluation λ_{max}	2nd Evaluation ϵ
p-Aminoacetophenone N,N-Dimethyl-1-naphthylamine	538	43,000	539	41,900
p-Aminobenzonitrile N,N-Dimethyl-1-naphthylamine	528	38,000	527	38,900
p-Aminobenzoic acid N,N-Dimethyl-1-naphthylamine	535	47,000	539	39,270
Sulfanilamide N(1-Naphthyl)ethylenediamine	544	33,000	545	27,400
Sulfanilamide 1-Amino-7-naphthalenesulfonic acid	524	44,700	526	44,300
Diaminodiphenylsulfone 1-Amino-7-naphthalenesulfonic acid	528	39,000	528	43,700
Sulfanilamide N,N-Dimethyl-1-naphthylamine	529	36,700	529	37,633
p-Aminobenzonitrile N-Phenyl-1-naphthylamine	556	40,300	556	49,230
p-Aminoacetophenone N-Phenyl-1-naphthylamine	565	43,000	568	52,170
p-Aminobenzoic acid N-Phenyl-1-naphthylamine	563	41,700	565	50,970
1-Amino-4-chloro-3-toluenesulfonic acid 1-Amino-7-naphthalenesulfonic acid	535	28,700	538	35,833
4-Aminoacetophenone N(1-Naphthyl)ethylenediamine	552	31,300	555	34,100
1-Amino-2,5-dichloro-4-benzenesulfonic acid 1-Amino-7-naphthalenesulfonic acid	540	31,300	511	35,630
Sulfanilic acid 1-Amino-7-naphthalenesulfonic acid	531	40,000	533	41,570
5-Chloro-2-aminoanisole 1-Amino-7-naphthalenesulfonic acid	548	33,700	549	32,000
Diaminodiphenylsulfone 1-Amino-7-naphthalenesulfonic acid	528	44,000	528	44,130

TABLE A-13 (Continued)

Reagent	1st Evaluation λ_{max}	1st Evaluation ϵ	2nd Evaluation λ_{max}	2nd Evaluation ϵ
Sulfanilamide 1-Amino-7-naphthalenesulfonic acid	523	51,300	525	44,270
p-Aminobenzoic acid N-Phenyl-1-naphthylamine	564	49,700	564	51,970
Diaminodiphenylsulfone N-Phenyl-1-naphthylamine	566	47,000	562	51,633
Sulfanilamide N-Phenyl-1-naphthylamine	558	46,300	565	49,467

TABLE A-14 STORAGE TESTS OF RDX REAGENTS[a]

Reagent	Initial		7 Days		14 Days		21 Days		28 Days		35 Days	
	Color	Limit	Color	Limit	Color	Limit	Color	Limit	Color	Limit	Color	Limit
p-Aminobenzoic acid N-Phenyl-1-naphthylamine	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4
p-Aminoacetophenone N-Phenyl-1-naphthylamine	Straw	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4
Diaminodiphenylsulfone N-Phenyl-1-naphthylamine	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4
p-Aminobenzonitrile N-Phenyl-1-naphthylamine	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Pink-brown	0.4	Pink-brown	0.4	Pink-brown	0.4
Procaine N,N-Dimethyl-1-naphthylamine	Colorless	0.4	V lt pink	0.4	V lt pink	0.4	V lt pink	0.4	V lt pink	0.4	V lt pink	0.4
Sulfanilamide N-Phenyl-1-naphthylamine	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4	Lt pink	0.4

(a) All reagents consisted of 0.5 g of each of the primary amine and coupling agent on 150 ml 50/50 HoAC/H_2O.

TABLE A-15 EVALUATION OF RDX REAGENTS ON VARIOUS SUBSTRATES[a]

Substrate	Color	Composition	Detection Limit, μg	Remarks
Papers				
20# Bond	White	100% cotton	0.4	(b)
16# Bond	Yellow		0.4	(b)
Onion skin tissue	White	25% cotton	4.0	
Plain, long grain	White		0.4	(b)
Index card	White		0.4	
File folder	Straw		0.4	
File pocket, glazed	Dk.brown		4.0	(b)
File folder, glazed	Med.brown		4.0	(b)
Blotter paper	White		0.4	
Xerox copy paper, coated	White		0.4	(b)
Construction paper	White		0.4	
Notebook filler	White		0.4	
Legal pad	Yellow		0.4	(b)
Grocery bag	Brown		4.0	
Wrapping paper	Brown		4.0	
Envelopes				
Letterhead bond	White		0.4	
Airmail	White/blue		0.4	
Business	White		0.4	
#10 airmail	White		0.4	
Clasp envelope	Lt.brown		4.0	Glue gives a weak positive response
Clasp envelope, glazed	Med.brown		4.0	(b)
Utility shipping bag	Med.brown		4.0	
Styrdite shipping bag	Med.brown		4.0	

TABLE A-15 (Continued)

Substrate	Color	Composition	Detection Limit, μg	Remarks
Cardboards				
Posterboard	White		0.4	(b)
Lightweight cardboard	Gray		4.0	
Medium weight boxboard	Brown		40.0	
Corrugated, coated	White		4.0	
Corrugated	Brown		40.0	
Miscellaneous				
Accohyde	Cream	Vinyl	4.0	
Polyethylene sheet	Clear	Polyethylene	4.0	
Wood	Tan	Pine	40.0	
Leather, vegetable tanned	Med.brown	Calfskin	--	Leather turns dark and brittle
Cloth	White	Cotton	0.4	
Foam	White	Polyurethane	4.0	

(a) Substrate sprayed first with a suspension of 10 g zinc dust in 100 ml benzene followed by a solution of 0.3 g procaine and 0.3 g N,N-dimethyl-1-naphthylamine in 100 ml 50/50 HoAc/H_2O.

(b) Actual limit detected but the reagent might not be useful to this level in other situations.

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